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TRANSPORTATION IMPACT STUDIES: A REVIEW WITH EMPHASIS ON RURAL AREAS

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RESEARCH REPORT 2

OCTOBER 1974

DEPARTMENT OF TRANSPORTATION
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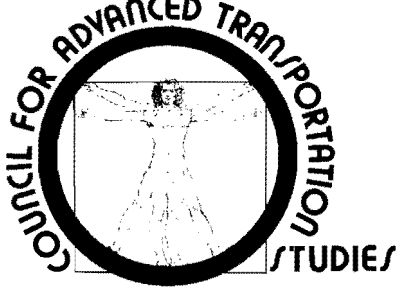

The University of Texas at Austin

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16. Abstract

Since highway improvement constitutes the most prevalent activity in transportation systems change during recent years, this report focuses on a review of the results from highway impact studies, principally those conducted in rural areas. It was found that most impact studies concentrate on measuring changes in land value, land use, business activity, industrial location and manufacturing growth. Very little investigation has been made of the impact on the social characteristics of rural communities or in the area of general community response. Most studies have been of limited character in that they concentrate on the effects which occur in the vicinity of interchanges, by-pass routes, and rural routes. Conclusions differ depending upon the geographical areas in which particular studies are conducted. As a result, it is difficult to draw inferences about highway impact on rural areas in general.

Methodologies used in highway impact studies usually involve one or a combination of the following: (1) before-and-after study; (2) survey-control area study; (3) case study; (4) multiple regression analysis. These categories are not mutually exclusive (e.g., most studies involve some comparison between conditions in a period before and in a period after the improvement). The limitations of the before-and-after technique, even when a control area is used to check the findings for a study area, suggest the need for a continuous study technique and the refinement of existing modeling techniques.

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EXECUTIVE SUMMARY

INTRODUCTION

The close connection between the development of interurban transportation and attendant changes in land development, economic activity and community response has been the subject of a great number of impact studies, especially after the initiation of the National System of Interstate and Defense Highways established by The Federal Aid Highway Act of 1956. As part of a research project designed to develop planning tools for use by government and citizen groups in serving the transportation needs of rural areas, this literature review has been conducted in order to evaluate the current state of the art in measuring the impact of changes in transportation, especially in rural areas.

PROBLEM STUDIED

The aim of the literature review was to define and evaluate the various methodologies used to measure transportation-related impact; to summarize the most important findings to date; and to recommend an appropriate direction for future studies. Most of the studies reviewed were conducted in the period between 1960 and 1970, since it was assumed that current methodology reflects experience gained from earlier work. Also, the most important interurban transportation system, the interstate highway, was constructed mainly after 1960.

RESULTS ACHIEVED

The studies reviewed were classified into four categories (these are not mutually exclusive) according to the following criteria:

(1) The nature of the transportation facility (i.e., highway, rail, etc.);

(2) The kind of area examined in the study (e.g., by-pass area, rural area, interchange area);

(3) The type of effect measured (changes in land use, land value, economic activity, etc.);

(4) The methodology employed in the analysis of impact.

Most studies of impact in rural areas concentrate on the effect of highway improvement, particularly the interstate system. Thus limited-access highways have received the most attention, although arterials without access-control and even farm roads have been studied to some degree. A few studies deal with the effect of new airports and with the importance of rail and bus service, but no report reviewed deals with the effect on rural areas of decreased rail service.

Since most impact studies in rural areas are concerned with highway improvement, the main body of the literature focuses on effects at interchange areas, by-pass routes, and along rural highways.

The impact is usually measured in terms of the effect on one or more of the following:

(1) Land use
(2) Land value
(3) Business activity
(4) Industrial and manufacturing growth
(5) Social characteristics of the community affected
(6) General community response (i.e., attitudes, behavior, etc.)

Out of concern for measuring the costs and benefits of highway improvements, the greatest number of studies concentrate on land value, land use, and business activity. While a reasonable amount of the literature deals with manufacturing growth and relocation in rural areas, very little work to date gives any in-depth analysis of the effect of transportation improvement on the social characteristics of rural communities, and still less work has been done in the area of general community response.

In terms of land value, land use, business activity, and manufacturing growth, most studies have concluded that the results of highway improvement are favorable to the rural community. Most by-pass studies, for example, have attempted to show that declines in land value and decreases in business activity are either temporary or are offset by later growth, which is usually attributed to the highway's influence.

However, the data and the conclusions from the highway impact studies reviewed to date do not provide predictive tools for the transportation planner. Conclusions are often confirmations of the obvious (e.g., that traffic-serving businesses are the first to develop at interchange areas), or else they are limited to the specific region studied and thus provide little that may be used to formulate hypotheses about the general nature of highway improvement impact in rural areas or on small communities. No study can rise above the limitations of the methodology upon which it is based, and most highway impact studies have been subjected to severe criticisms on methodological grounds.

The methodology used to evaluate transportation impact usually involves one of, or a combination of the following:

(1) Before-and-after technique
(2) Survey control area technique
(3) Case study technique
(4) Multiple regression analysis
(5) Projected land use/value relationship
(6) Neutral road comparison method

Most studies employ some use of the "before-and-after" technique. In these studies the before period usually is defined as a 2-5 year time span prior to the transportation improvement, and the after period determined as a 2-5 year period after the facility has been completed. The technique measures the value of some of the characteristics (e.g., land value) of an area in the before period and compares this value with that measured in the after period. The difference is said to be the effect of the transportation facility.

There are several theoretical and practical disadvantages to the simple before-and-after method. First, the technique reveals little or nothing about trends prior to the improvement.(In reality the length of the "before" period is undefinable because it is not known when knowledge of a proposed improvement begins to influence the development of an area.) Second, it does not isolate the impact of the change in the transportation system from other sources of influence.

The survey-control area technique attempts to isolate the effect of the transportation facility by comparing the results in the area being studied with those from a similar area (the control area) which has not experienced a change in transportation. The difference between the results is said to be the "impact" of the change.

In theory, the survey area and the control area would have to be exactly alike in all respects just prior to the improvement, and the factors affecting the development of each area would also have to be identical except for the change in the transportation facility.

These conditions are almost impossible to meet. In practice, the control area chosen is usually itself susceptible to some, often negative impact from the facility. Especially in small rural communities, it would be difficult to find a control area not influenced by any major change in the transportation system. In any case, the multitude of transportation and non-transportation related factors which produce the effects to be measured create a more complicated situation than the assumptions of the survey-control area method would account for.

The "projected land use/land value relationship" approach and the "neutral road comparison method" are techniques which attempt to compensate for some of the limitations on the other methods. The first involves comparing a projection of land use/value, assuming that the facility had not been built, with that which actually took place. The second method, primarily used to predict changes in business activity, compares alternative highway locations to a hypothetical, "economically neutral" road. Both methods are limited in scope, and both depend on the accuracy of the forecasting techniques, which are at best difficult to evaluate.

The case study approach deals with a detailed analysis of events which take place following the improvement of a facility. Consequently, although detailed knowledge may be obtained about specific possibilities in one area, the results are not claimed to have general validity.

Multiple regression analysis, a statistical technique which relates changes in one dependent variable to the behavior of a number of independent variables, has in most cases been used where appropriate "control" areas

could not be found. This technique requires more information about non-transportation related factors than do other techniques. Consequently, it may be used to analyze the complex cause/effect relationship in a more complete manner than do the other approaches.

In practice, however, it has not been possible to include all relevant factors because of a general lack of knowledge about how to determine relevancy or how to quantify certain qualitative characteristics. However, these limitations do not apply to the methodology as such, but rather to its present state of development.

UTILIZATION

This review should be of interest to local, state, and federal agencies and to research groups planning future impact studies, especially in rural areas. It summarizes some of the more important findings to date and evaluates the current state-of-the-art, and it recommends guidelines for future studies. For the convenience of the reader, an annotated bibliography, containing over seventy references, is included.

CONCLUSIONS

In order to compensate for the limitations discussed above, an ideal study methodology will have to meet the following requirements:

(1) The study period must be long enough to include all the important changes in both the community and the transportation system.

(2) The study should be continuous over time to reveal the general trends in community development both before and after changes in the transportation system.

(3) The geographic limits of the study area must incorporate the entire community, including extraterritorial controls.

(4) The effects on the community examined must include all physical, social and economic factors of importance for characterizing the community and for measuring the community's potential for growth and development.

(5) The study of the transportation system must include all of the modes serving or influencing the community, and the study method must make it possible to determine what characteristics of the transportation system are of the greatest importance for community development.

PREFACE

This is the third in a series of reports describing the activities and findings as a part of the work done under the research project entitled, "Transportation to Fulfill Human Needs in a Rural/Urban Environment." The project is divided into five topics, and this is the first report under the topic "The Influence on the Rural Environment of Interurban Transportation Systems." This report is a review of the findings of previous studies in the field of research on transportation impact in rural areas, an analysis of the methodologies most commonly used, and a proposed methodology suitable to the study of the impact of transportation changes on rural communities. It is intended to provide both a picture of the state-of-the-art and a summary of specific results, especially those which have a direct bearing on the study of interurban transportation in rural environments.

This review has shown the need to re-evaluate the methodology of impact studies in general and to develop from specific case studies a methodology appropriate to transportation systems impact on small communities.

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I. INTRODUCTION

Mobility is and has always been a major characteristic of American society. Land development, economic activity, and social habits have all been dependent upon this feature of American life. The major development of the nation was made possible with the expansion of the railroad system across the continent. Cities with their attendant economic activities grew up at the focal points in the transportation system, those locations where rail lines crossed each other and where the local road systems were connected to the railroads. Later on, when the automobile opened new possibilities for private mobility, the major investment in transportation facilities went for the building of highways, and there followed an increase in economic activity and changes in social habits which were as dramatic as those produced by the development of the railways.

The close connection between highway transportation, land development and economic activity has been subject to a great number of studies which have attempted to relate public investment in highway facilities to social and economic changes in adjacent land and communities. These studies have been of particular concern in the time period after the National System of Interstate and Defense Highways was established by the 1956 Federal Aid Highway Act. These impact studies have become more and more comprehensive and have increasingly provided valuable information about different types of effects caused by transportation improvements in different areas.

PURPOSE AND SCOPE

Background

The purpose of this report is to review both the findings and the methodologies developed for measuring and analyzing the various kinds of impact produced by changes in transportation, especially the improvement in highway facilities. The literature review is an integral part of a research project, "The Influence on the Rural Environment of Inter-Urban Transportation Systems." This research project, sponsored by the U. S. Department of Transportation,

the Council for Advanced Transportation Studies, and the University of Texas at Austin, is directed toward developing a methodology capable of ascertaining the nature of a rural community's potential for development as influenced by either existing or planned interurban transportation systems. Such a methodology will be of great value in transportation and land use planning as well as for those living in rural communities to understand the effect that changes in the transportation system might have on their way of life, given the local economic and human resources.

Communities in the eastern area of Texas are considered appropriate for use in developing such a predictive methodology. There is a large number of communities with populations between 1,000 - 50,000, and major changes in the transportation system have occurred in this area during the last two decades. Initially it was felt that a review of existing literature covering transportation systems impact was necessary in order to provide a thorough understanding of the complex cause-effect relationship between physical and operational changes in the transportation system and community development. A definition of the "state-of-the-art" was necessary prior to the development of an overall research methodology and of specific study techniques suited to the different aspects of transportation systems impact. The literature review, together with preliminary studies of local social and economic conditions in the first community to be examined and a survey of information available on transportation systems and community development, has resulted in a more concrete work plan for the first year of the research and a more specific direction for the two following years.

The literature review will continue throughout the entire study period; this report constitutes a summary of the literature examined during the first twelve months of the project. Additional studies will be reviewed as published, and as the research project advances and as the scope of the project is widened to include a greater variety of community impact, appropriate literature will be reviewed.

Literature Sources Studied

The available literature sources include a variety of textbooks, research reports, and articles. The literature studied, or to be studied, may be divided into three broad categories:

(1) General theoretical background;

(2) Previous research reports;

(3) Specific modeling efforts.

The first category, general theoretical background, includes specific subjects in textbooks on transportation planning, land use planning, community planning, sociology, and economics, as well as a variety of papers describing general techniques of research and modeling. Studies in this category are not included in the first report, but will be referred to in the reports dealing with specific areas of transportation systems impact.

The second category, previous research reports, includes impact studies, and thus gives factual information about impact as observed in a great number of research projects. Most of the research has been conducted by universities or by state and federal highway agencies. These studies in most cases prove that changes in transportation systems do have an influence on development and activities in adjacent communities, and they attempt to measure the effect in each case as much as possible. However, because of the variety of individual cases, these studies cannot be used to predict the degree of the impact of proposed changes in a transportation system on communities other than those studied.

The last category, specific modeling efforts, includes the relatively few previous efforts on modeling the impact of highways on specific adjacent areas. Because of the amount of literature dealing with some aspect of transportation impact, the literature reviewed has been selected so as to include what would be of importance for the research project to date. So far, therefore, most of the literature reviewed deals with transportation systems impact on land use, land values, business activities, and general community economics.

The major purpose has been to locate and trace all previous studies which may be of sufficient importance to warrant further examination. It is believed

that the results will yield not only a comprehensive summary of previous findings, but also important information about the different methodologies that have been used. This should both clarify the complexity of the problem and disclose the shortcomings of other research in the field.

Most studies reviewed to date are from the period 1960 - 1970. Studies prior to 1960 are given less emphasis, as it is believed that later research reflects experience gained from earlier methodology. Also, the most important interurban transportation system of today, the interstate system, was to a great extent constructed after 1960.

CHARACTERISTICS OF THE IMPACT STUDIES REVIEWED

So far, practically all of the impact studies deal exclusively with the effect of interurban highways, mainly the interstate system and the effect of circumferential or through routes in urban areas. Thus limited-access highways have received the most attention. However, arterials without access-control and even farm roads have been studied to some degree.

Geographically, there are highway impact studies from every part of the nation. Only in Texas has there been carried out a series of studies, using the same methodology.[1] Of the literature reviewed, these give the most comparable information. Because of the wide variance in study techniques and the dates of different studies, it has not been found appropriate to try to compare studies from different parts of the nation in order to find any specific difference in impact according to geographical location. Although the

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[1] C. V. Wootan and H. G. Meuth, "Economic Impact Study, Temple, Texas," Texas Transportation Institute, Bulletin 14, 1960; J. L. Buffington and H. G. Meuth, "Economic Impact Restudy, Temple, Texas," Texas Transportation Institute, Bulletin 27, 1964; J. L. Buffington, "Economic Impact Study, Rural Area East of Houston, Texas," Texas Transportation Institute, Bulletin 37, 1967; "Economic Impact Study, Chambers County, Texas," Texas Transportation Institute, Bulletin 39, 1967; "Economic Impact Study, Huntsville, Texas," Texas Transportation Institute, Bulletin 38, 1967; "Economic Impact Study, Conroe, Texas," Texas Transportation Institute, Bulletin 40, 1967; "Economic Impact Study, Waxahachie, Texas," Texas Transportation Institute, Bulletin 35, 1966; "Economic Impact Study, Merkel, Texas," Texas Transportation Institute, Bulletin 36, 1966.

areas studied include both urban and rural communities, in this literature review, studies from rural communities have been given the most emphasis.

"Highway improvements" are in most cases defined as the construction of new highways. A new facility may be located relatively close to and serve the same traffic as an old facility, or it may be a new link in the overall road network, thus creating new travel patterns. Most of the previous research has concentrated on new interchange areas or on bypass routes, locations where the most obvious changes take place.

All studies involve definition of the area in which the effect is measured. Different types of areas have different characteristics and may require different study techniques. Consequently, most studies concentrate on one type of area. Study areas may be divided into two major categories, urban and rural. In some cases a third category, "urban fringe," is used. However, it may be difficult to give a unique definition of each area type. Studies of small towns can in most cases be said to be studies of rural areas.

In addition to type of area, the previous studies may be classified according to type of highway improvement which has occurred. It is reasonable to use three categories:

(1) Interchanges,

(2) Bypass routes,

(3) Rural highway routes.

Studies of the two first categories involve both rural and urban study areas.

The basic approach has involved the study of changes in land development and activities in a period before and a period after completion of the new facility. Typically, changes in land use, business activities, etc., are related to the highway improvement. Such variables as distance to nearest city, population density and traffic volumes are also investigated in some studies, as is the effect of proximity to the highway improvement.

METHODOLOGIES USED

The methodology used to evaluate such changes as alterations in land use, land value, economic activity, etc., usually involves one of, or a combination

of the following:

(1) Before-and-after study,

(2) Survey-control area study,

(3) Case study,

(4) Multiple regression analysis,

(5) Other study techniques.

The "before-and-after study" method, combined with one of the other methods, is used primarily to determine the effect of road improvement. In these studies, the "before" period includes 2 - 5 years prior to the highway's construction, and the "after" period usually spans 2 - 5 ayears following the completion of the highway. The before-and-after method is most often used to study the effect of a new highway in an area which did not have previous roadway, e.g., an area where a new bypass is built.

The "survey-control area study" method is the most common technique used to isolate the influence of a highway on nearby land, often in combination with the before-and-after study method. The procedure is to measure development both in the study area located adjacent to the facility and in a control area located far enough from the highway to have been unaffected by the facility. The change between the before period and the after period in the control area is compared with the change in the survey area, and the effect of the highway is measured as the difference between the two.

The "case study" approach deals with a rather detailed analysis of events which have taken place nearby a highway facility. Such events may be the construction of new industrial plants or new commercial development. By examining selected cases with emphasis on their relationship to the highway, the case studies may indicate the variety and the extent of significant changes attributable to the highway.

Multiple regression analysis, a statistical technique which relates changes in one dependent variable to the behavior of a number of different independent variables, has been used in cases where appropriate control areas could not be found or to check the results of the survey-control area method. Changes in land development or land value, the dependent variables, are assumed

to be the products of many different factors, both highway and non-highway related. The most significant results are achieved by partial correlation, requiring that the different variables be represented quantitatively.

Techniques other than the above mentioned, or variations of them, were also used in the studies reviewed. Among these were the "projected land use/ value relationship approach" and the "neutral road comparison" method.

The first of these two techniques involves comparing the land development which might have occurred had the highway not beeen built with the development which actually took place. The "neutral road comparison" method compares alternative highway locations to a hypothetical, economically neutral road.

All of the techniques reviewed require that highway and non-highway related impact be separated. The non-highway related impact is usually analyzed in terms of such factors as distance to nearest trading center or city, population density, and area-classification (urban, suburban, and rural).

Regardless of the methodology used, most of the studies examine the average effect in the study area. Only a few studies examine the geographical distribution of the effect, usually by classifying areas as within or outside some specified distance from the highway facility. Further comment on the limitations of current methodology is reserved for the last section of this report. It is first necessary to review the particular findings of transportation impact studies, especially those concerned with small town and rural areas.

CHAPTER II. PREVIOUS STUDIES OF THE IMPACT OF TRANSPORTATION IMPROVEMENT IN RURAL AREAS

II. PREVIOUS STUDIES OF THE IMPACT OF TRANSPORTATION IMPROVEMENT IN RURAL AREAS

IMPACT OF HIGHWAY IMPROVEMENT

The impact of highway improvement or location on rural communities is usually measured in terms of the effect on one or more of the following:

(1) Land use
(2) Land value
(3) Business activity
(4) Industrial location and manufacturing growth
(5) Social characteristics
(6) General community response

While this grouping may help to clarify the basic relationship between a change in the transportation system and the types of community characteristics affected, one should have in mind the interaction between the factors, e.g., between land use and land value.

Impact on Land Use

Interchange Areas. Most of the highway impact studies investigate land use adjacent to a highway. Because changes in land use due to a highway facility tend to occur primarily at interchanges, a number of the studies deal only with interchange areas.

It is important to know what development is likely to take place in an interchange area and how this development varies with interchange type, access, and geographical location. A study of 66 interchanges along I-94 in Michigan shows a significant difference in development for different types of interchanges.[2] The findings are summarized in Table 1.

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[2] R. H. Ashley and W. F. Berard, "Interchange Development Along 180 Miles of I-94," Highway Research Record No. 96, Highway Research Board, 1965, pp. 46-58.

TABLE 1. PERCENT OF LAND DEVELOPMENT ADJACENT TO HIGHWAY INTERCHANGES

Type of Development	Interchange Type		
	Closed	Partial	Full
Commercial	-	7.1%	40.6%
Industrial	-	-	5.2
Residential	14.8%	7.1	14.1
Governmental	-	21.5	6.6
Vacant	85.2	6.6	33.5
	100.0%	100.0%	100.0%

This table suggests that different land uses depend upon the kind of access available. "Closed" interchanges are intersections of two limited-access highways. Thus, adjoining land is accessible only by indirect routes. "Partial" interchanges serve on-and-off traffic in only one direction. "Full" interchanges allow the motorist to leave the freeway in either direction. Residential development does not seem to require accessibility at the interchange whereas industrial, governmental and particularly commercial, seem to require immediate access.

The same study also examines full interchanges in order to show the relation between development and geographical location. The interchange locations were classified as:

(1) Major city routes: Major routes, population $>$ 10,000

(2) Secondary city routes: Secondary routes, population $>$ 10,000

(3) Small town: Main intersection, population $<$ 10,000

(4) Rural: All interchanges not associated with a city or a town.

Table 2 shows the result from this aspect of the study. The study ranks land-use as follows: commercial, industrial, residential, and vacant. It should be noted that the table shows only the highest ranked land use in each quadrant in the interchanges. Consequently, the exact nature of land development in each quadrant is not truly represented. The governmental classification is used for land owned by governmental agencies and in this study is not considered available for development.

TABLE 2. QUADRANT DEVELOPMENT AROUND FULL INTERCHANGES

Type of Development	Interchange Location			
	Major City Route	Secondary City Route	Small Town	Rural
Commercial	78.1%	40.1%	44.2%	22.4%
Industrial	-	15.4	1.9	2.6
Residential	9.4	11.5	15.4	17.1
Governmental	-	9.6	3.9	9.2
% of Total Developed	87.5%	76.9%	65.4%	51.3%
% of Total Vacant	12.5%	23.1%	34.6%	48.7%
Total	100.0%	100.0%	100.0%	100.0%

Since this review is most concerned with transportation impact in rural areas and small towns, the results for these two locations are of most interest.

Twice as many quadrants have commercial land use in small towns as in rural areas. Also significant is the relative lack of industrial development near interchanges in small town and rural areas when compared with secondary city routes.

To give an idea of the magnitude of development, as well as the relative kind of land use, Table 3 shows the average number of commercial activities by type. In this table is also included the average number of activities from a study of interchanges in Pennsylvania.[3]

TABLE 3. NUMBER OF DEVELOPMENTS (WITHIN 1000 FT.) PER FULL INTERCHANGE

Interchange Location	Service Stations	Restaurants	Motels	Shopping Centers	Other Sales Uncommitted (a)
Major City Route	3.38	2.38	1.25	0.38	0.38
Secondary C. Route	1.38	0.46	0.15	0.08	0.54
Small Town	1.23	0.54	0	0	0.62
Rural	0.44	0.28	0	0	0.50
Average, Michigan	1.33	0.71	0.31	0.08	0.52
Average, Pennsylvania (b)	0.6	0.3	0.3	0	0.6

[a] Known sales where no construction has started.

[b] Figures from 36 non-urban interchanges.

[3] O. H. Sauerlender, R. B. Donaldson, and R. D. Twark, "Factors That Influence Economic Development at Non-urban Interchange Locations ", Pennsylvania State University, 1967.

According to the Michigan study, service stations and restaurants represent the only kind of interchange development in small towns and rural areas. A rather high number of uncommitted sales indicates that about one property per two interchanges is held for future use. The Pennsylvania study, however, shows a relatively high number of non-highway oriented businesses, although even here service stations, restaurants and motels account for most of the development.

Two recent studies, from interstates in North Carolina and Indiana,[4] also show the percentage of developed land in interchange areas. Tables 4 and 5 give a comparison between the findings from the two studies.

TABLE 4. PERCENTAGE DEVELOPED QUADRANTS, AND AVERAGE NUMBER OF DEVELOPMENTS PER INTERCHANGE

Interchange Location	NORTH CAROLINA		INDIANA	
	Developed Quadrants	Developments per Interchange	Developed Quadrants	Developments per Interchange
Urban	79%	6.5	NA	18.3
Suburban	70%	5.5	NA	6.3
Rural	35%	1.5	NA	2.4

[4] Lawrence P. Fabbroni, "Land Use Development at Interstate Interchanges in Indiana," Joint Highway Research Project, Purdue University, Project C-36-70D, May 1973, pp. 1-85 and Appendix; W. F. Babcock and S. Khasnabis, "Land Use Changes and Traffic Generation on Controlled Access Highways in North Carolina," North Carolina State University at Raleigh, 1971, pp. 1-20.

TABLE 5. INTERSTATE INTERCHANGE DEVELOPMENT (PERCENTAGE) BY LOCATION OF INTERCHANGE

Development	NORTH CAROLINA (a)			INDIANA (b)		
	Urban	Suburban	Rural	Urban	Suburban	Rural
Gas, service stations	27	41	70	28.4	44.7	58.2
Truck stops	5	4	5	1.6	2.4	5.7
Restaurants	1	5	5	10.2	6.1	4.5
Motels	8	12	5	6.3	5.5	8.5
Shopping Centers	3	4	-	-	-	-
Office & Institutions	11	4	2	-	-	-
Retail & misc. sales	21	11	6	-	-	-
Public facilities	-	-	-	3.1	4.2	9.1
Residential	-	-	-	14.5	11.6	8.0
Trailer parks	-	-	-	3.1	3.0	3.4
Educational	-	-	-	-	0.6	0.5
Commercial	-	-	-	19.2	10.3	1.7
Industrial	24	19	7	12.6	12.2	5.7

[a]Approximate percentages.

[b]Actual figures from the report. For some unexplained reason, the figures do not total 100.0% in each category.

These two studies show that service stations are the dominating source of land use near interchanges in rural areas. Also indicated is that industrial and commercial use is much more likely in urban or suburban areas. With regard to motels and restaurants, however, these two studies from North

Carolina and Indiana seem to indicate no significant difference for interchange location.

Despite many similarities in land development at different interchange locations, too little is known about the underlying factors to be able to predict future land use at a specific interchange. One major factor, time, is barely considered in the studies reviewed. This does not, however, mean that time is without interest when short or long term impact on a community is to be determined.

The interchange studies in general seem to indicate:

(1) Highway-oriented services catering to the highway traffic are the first to develop and are the major sources of land use at interchange areas.

(2) The second most important land-use category to develop at interchanges is that of commercial activities which need to be easily accessible from highways. Such activities are shopping centers, some industry, and outdoor theaters.

(3) The third group of land-use categories to develop at interchanges may include non-highway oriented activities (e.g., individual stores) and individual residences. This group has no especially high need for direct access.

Analysis of Interchange Development. In the Pennsylvania study[6] the following variables were included in the analysis of each interchange area in addition to the number and kind of developments: type of interchange, average daily traffic volumes on the interstate and the crossroute, distance to the nearest urban area, age of interchange, topography within the interchange community, population characteristics, and market value characteristics. No complete regression analysis was made, but simple correlation analysis shows that the most important variable is traffic volume expressed in terms of Average Daily Traffic-count (ADT) on the cross-route. Other important factors are topography, distance from nearest urban area, and population change. Table 6, page 16, shows the result from this study.

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[5] Sauerlender, et al., "Factors That Influence Economic Development at Non-urban Interchange Locations."

TABLE 6. CORRELATIONS OF VARIABLES WITH TOTAL HIGHWAY-ORIENTED DEVELOPMENT

(a)

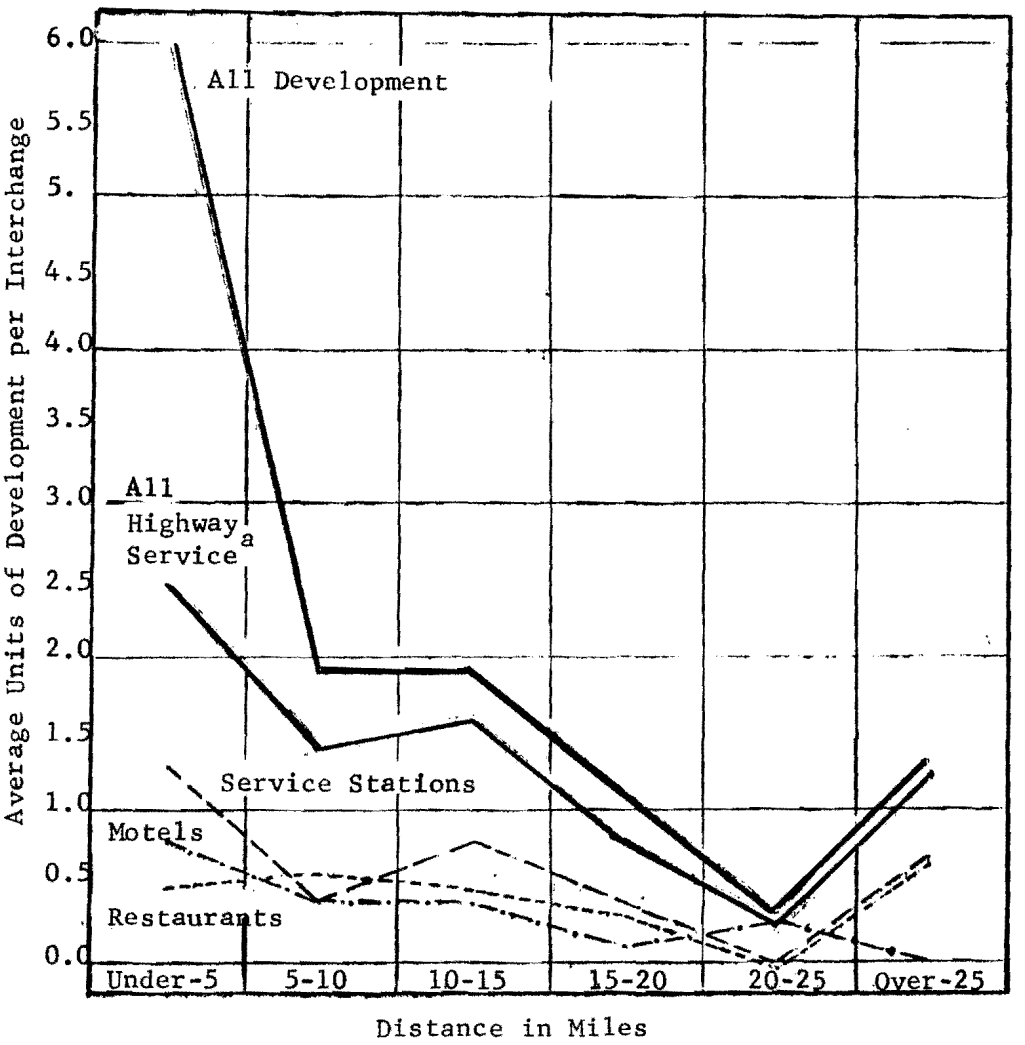
Variable	Correlation Coefficient	Proportion of Variation Explained (percent)
Cross-Route Average Daily Traffic (ADT)	0.514[b]	26.4
Topography (Average Slope)	-0.388[c]	15.1
Distance from Nearest Urban Area	-0.360[c]	13.0
County Population Change	0.333[c]	11.0
Local Municipal Market Value Change	0.320	10.2
Local Municipal Population Change	0.305	9.3
Nearest Urban Area Population Change	0.289	8.4
Nearest Urban Area Population Change	0.235	5.5
Age of Interchange	-0.195	3.8
County Population	0.188	3.5
Interstate Average Daily Traffic (ADT)	0.174	3.0
Local Municipal Market Value	0.135	1.8
Local Municipal Population	0.099	1.0

[a]Total Units include only service stations, restaurants, and motels. Only complete interchanges were considered.

[b]The correlation coefficient is significant at the 1 percent level.

[c]The correlation coefficient is significant at the 5 percent level.

The same report also describes the effect of an increasing distance to the nearest urban area. There seems generally to be a drastic reduction in the number of developments where the distance is more than 5-10 miles. The results are shown in Figure 1, p. 17.



[a]Highway Service, Service Stations, Motels, Restaurants.

Source: Figure from Sauerlender, et al., "Factors that Influence Economic Development at Non-urban Interchange Locations," Pennsylvania State University, 1967.

Figure 1

DEGREE OF DEVELOPMENT AND DISTANCE FROM NEAREST URBAN AREA

The amount of development in an interchange area will depend upon interchange type, characterized by design type and access control. The Pennsylvania study indicates that of all design types, full diamond and full and partial cloverleaf attract more interchange development than other types.[6] (All "full" interchanges provide access to each interchange quadrant from both directions on the main route.) However, other studies have indicated that the most desirable location for highway-oriented development is the quadrant with a direct exit ramp from the main highway. In the case of diamond and cloverleaf design types, these quadrants are often referred to as "right hand quadrants."[7]

Table 7 shows clearly how different types of activities tend to locate according to their dependence upon access from the main highway.

TABLE 7. DISTRIBUTION OF LAND DEVELOPMENT, IN PERCENT, BY HIGHWAY INTERCHANGE QUADRANTS

Land Use	Quadrants	
	Right Hand	Other
Highway related	59%	41%
Commercial	51	49
Residential	50	50
Agricultural	49	51
Vacant	48	52
Institutional	43	57
Industrial	43	57

[6] Sauerlender, et al., "Factors That Influence Economic Development at Non-urban Interchange Locations."

[7] Floyd I. Thiel, "Highway Interchange Area Development," Public Roads, Vol. 33, No. 8, June, 1965; Martin M. Skin, "Highway Interchange Development: Some Recent Findings," Public Roads, Vol. 35, No. 11, December, 1969.

As expected, highway related activities tend to concentrate near the off-ramps, while industrial activities are more frequently located in other quadrants. The rather equal percentage of vacant land in both right-hand and other quadrants may indicate that most of the interchange areas were not fully developed and that the distribution of land uses consequently was not influenced by scarcity of land.

Bypass Routes. A number of impact studies from Texas,[8] have examined what changes are likely to take place in the area along a new bypass route. The before-and-after study method is the technique used in these studies to obtain information about the impact of the bypass route on adjacent land.

As the summary from four of these findings shows in Table 8, there is an obvious trend in the land use pattern, even though the area characteristics vary. The data from the period before construction of the highway facility shows that most of the land was held for agricultural use. For some areas, a significant part is classified as "held for future use." To what degree this is caused by the highway planning and purchase of right of way for the facility was not investigated in the study.

The most significant change in land use between the before and after periods is the decrease in agricultural land use and the increase in land held for future use. Real estate records showed that many of the properties shifted owners before they shifted land use. This indicates speculation in land caused by the construction of the bypass route. Therefore, the changes in land use which have taken place indicate more about anticipated future exploitation than about real changes in land use.

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[8] C. V. Wootan and H. G. Meuth, "Economic Impact Study, Temple, Texas," Texas Transportation Institute, Bulletin 14, 1960; J. L. Buffington and H. G. Meuth, "Economic Impact Restudy, Temple, Texas," Texas Transportation Institute, Bulletin 27, 1964; J. L. Buffington, "Economic Impact Study, Rural Area East of Houston, Texas," Texas Transportation Institute, Bulletin 37, 1967; "Economic Impact Study, Chambers County, Texas," Texas Transportation Institute, Bulletin 39, 1967; "Economic Impact Study, Huntsville, Texas," Texas Transportation Institute, Bulletin 38, 1967; "Economic Impact Study, Conroe, Texas," Texas Transportation Institute, Bulletin 40, 1967; "Economic Impact Study, Waxahachie, Texas," Texas Transportation Institute, Bulletin 35, 1966; "Economic Impact Study, Merkel, Texas," Texas Transportation Institute, Bulletin 36, 1966.

TABLE 8. CHANGES IN LAND USE FOR SOME AREAS ADJACENT TO NEW BYPASS ROUTES

AREA	Year	Agricultural	Timberland	Held for Future Use	Rural Residential	Urban Residential	Commercial, Traffic-serving	Commercial, Non-traffic-serving	Industrial	Institutional Municipal	Other
Rural area E. Houston	1954	6000	-	5500	500	500	10	10	50	5	625
	1962	3371	-	7600	657	517	11	15	360	17	652
	Change	-2629	-	2100	157	17	1	5	310	12	27
Chambers County	1955	22620	1320	535	130	-	0	2	55	2	1136
	1965	22513	1208	544	216	-	8	43	55	55	1158
	Change	-107	-112	9	86	-	8	41	0	53	22
Conroe	1958	9678	4672	3087	424	570	62	7	57	1743	0
	1965	6025	2904	7356	582	928	69	115	73	1921	327
	Change	-3653	-1768	4269	158	358	7	108	16	178	327
Huntsville	1954	4000	1600	1416	231	289	16	13	1	1007	227
	1964	3607	1374	1460	343	486	31	25	1	905	568
	Change	-393	-226	44	112	197	15	12	0	-102	341

Source: Buffington, "Economic Impact Study, Rural Area East of Houston, Texas;" "Economic Impact Study, Chambers County, Texas;" "Economic Impact Study, Huntsville, Texas;" "Economic Impact Study, Conroe, Texas."

The after-period in these studies varies from 2 - 5 years beyond the time when the bypass section was opened to traffic. Thus it may be said that the studies show only a short term effect on land use. As the area classified "held for future use" constitutes up to 70% of the study areas, the long term effect may be different from the short term effect.

It is often the case that change in land use depends largely upon distance to the highway facility. These studies from Texas show that the change is most likely to take place in the abutting tracts. The highway impact on land use studied in these cases is therefore limited to a very narrow strip along the facility. The number of abutting tracts according to land use is shown in Table 9, p. 22.

Rural Highway Routes. The highway effect upon agricultural land use found in the bypass-studies discussed above is not representative of the over-all effect of the interstate system in rural areas. In the bypass-studies most of the tracts were located just outside of towns ranging from 8,000 to 25,000 in population, and the resulting effect is caused by the combined effect of highway and nearness to a city.

Of the studies reviewed, only three from Texas[9] deal with the effect of construction of a new highway facility through a rural area. These studies cover a period beginning one year before construction and ending one year after the highway section was opened to traffic. In order to account for any external or general influences not attributable to the highway during the period, data were also collected from a control area that was similar to the study area in the before period.

These studies seem to indicate that there is no evidence of major change in land use as a result of the highway construction, except for the fact that parts of tracts of land are acquired for the highway right of way.

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[9] H. G. Meuth, "Right of Way Effects of Controlled Access Type Highways on a Ranching Area in Madison County, Texas," Texas Transportation Institute, Research Report 58-4, 1968; H. G. Meuth and J. L. Buffington, "Right of Way Effects on Controlled Access Type Highway on a Farming Area in Ellis County, Texas," Texas Transportation Institute, Research Report 58-5, 1969; H. G. Meuth, "Right of Way Effects of Controlled Access Type Highway on a Farming Area in Colorado and Fayette Counties, Texas," Texas Transportation Institute, Research Report 58-6, 1970.

TABLE 9. VARIATION IN NUMBER OF ABUTTING TRACTS ACCORDING TO LAND USE ALONG BY-PASS ROUTE

STUDY AREA	Periods Before And After	Agricultural	Timberland	Held for Future Use	Rural Residential	Urban Residential	Commercial, Traffic serving	Commercial, Non Traffic serving	Industrial	Institutional Municipal
Waxahachie	(a)			28	5	8	1	1	1	1
Chambers County	1947-55	43	5	21	0	0	0	0	0	1
	1960-65	43	4	22	4	0	5	1	0	2
Conroe	1952-58	15	25	43	5	6		0[b]	0	6
	1963-65	7	3	58	6	6		5	0	8
Huntsville	1950-54	14	16	1	2	0	0	0	0	6
	1960-69	3	9	24	8	4	7	2	0	6

[a]Difference between after period (1969-62) and before period (1951-55).

[b]No distinction made between the two types of commercial development.

Source: Buffington, "Economic Impact Study, Merkel, Texas;" Ashley, "Interchange Development Along 180 Miles of I-94;" Fabbroni, "Land Use Development at Interstate Interchanges in Indiana;" Babcock, "Land Use Changes and Traffic Generation on Controlled Access Highways in North Carolina."

Further findings state that the loss of land for right of way seems not to have any noticeable effect on the average net-cash operating-income of properties in the study area.

In most cases the new highway improved the farmers' access to the nearest trading center. The ones who continued to use their regular routes to town reported less traffic and congestion on those routes after construction of the new highway.

Most of the farmers whose lands were affected by the highway experienced an increase in travel distance necessary to operate the remainder of their tracts adjacent to the highway. The additional distance to reach these tracts varied from about .1 to 4 miles. In the three studies, the average of additional miles per farmer per year varied from 120 to 390 miles.

Impact on Land Values

The studies reviewed to date tend to verify that accessibility is a key catalyst for changes in land value. Since land value is a function of the possibility of economic activity, and since this possibility changes with ease of access, it is obvious that the value of land may vary with its connection to a transportation system.

Thus, land value may reflect the economic impact of the highway facility; in this way, land value might be considered an important indicator of both real and anticipated effects of the transportation system.

However, accessibility is only one factor and should not be regarded as isolated from traveller characteristics or land use characteristics. Different kinds of economic activities depend upon different groups of travellers (e.g., local traffic or through traffic); therefore, access has to be related to land use and, in some degree, to other general characteristics of the location of the study area.

Interchange Areas. The study of interchanges along I-94 in Michigan clearly shows that study area location and land use must be taken into consideration when land value is analyzed.[10] This study investigates land values for different land uses in full interchanges. Table 10, p. 24, gives a summary of the findings.

Table 10 shows that investors in service stations were willing to pay far more per acre than other investors. The difference is especially high at interchanges in rural areas. The main reason for this is probably the difference

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[10]Ashley, "Interchange Development Along 180 Miles of I-94."

in net annual return for other activities, which, unlike service stations, are more dependent on the general population density in the area. Service stations on the other hand serve the traffic, and it may be expected that traffic volumes are more important than the nature of the area in which the interchange is located. As service stations depend more upon direct access from the highway than other activities (see Table 7), it may be expected that land values vary considerably in the different quadrants according to the interchange design.

TABLE 10. CHANGES IN LAND VALUES BY LAND USE TYPE IN FULL INTERCHANGES

Interchange Location	Average Land Values ($ per acre) 1960 - 1964		Percent Change (a)	
	Service Stations	Other	Service Stations	Other
Major City Routes	54 653	8 600	441	227
Sec. City Routes	18 650	1 830	388	215
Small Town	11 100	995	641	205
Rural	26 470	512	627	161

[a]Period 1958 - 1959 compared with period 1960 - 1964.

Another reason for the difference between the price paid for service stations and that for other land uses may be the fact that the freeway was a relatively new concept in 1960, and thus the investor had little experience in calculating possible future profit. Therefore, these prices may express the investor's anticipations and ability to pay more than real, long-term changes in land value.

Bypass Routes. Four studies from Texas seem to indicate especially high increases in land value along bypass routes.[11] The before-after study method is used; to account for general increases in land value, a control area similar to the study area in the before period is also examined.

Since the construction of the new bypass route is the principal difference between the study and the control area during the after period, the divergence in land values between the two areas is attributed to the highway improvement. Possible factors other than the new highway facility are therefore not considered.

As can be seen from Table 11, p. 26, there is a significantly higher land value in the study areas during construction and the after period than in the control areas. The control areas seem to have a rather stable pattern with regard to land value. The land values in the separate study areas fluctuate to such a degree between one study period and another that it is difficult to see a clear pattern. What can be learned, however, is that there is a significant increase in land values, over and above what might be expected without the highway's influence, between the before and the after periods.

Table 11 gives the average sales prices per acre, regardless of land use. Since land value is highly dependent upon land use, a dominance in sales of land devoted to a given use in a particular period may explain the great variation in sales price between one period and another. However, without detailed information about land use or speculation, no definite conclusions may be drawn about the specific reasons for particular fluctuations in land value.

Increase in land values for improved areas is not shown in Table 11. The Texas studies indicate, however, that this is smaller than the increase for unimproved areas. One reason for this may be that improved lots are fixed in land use, and their prices normally do not respond so readily to changing surroundings as do those for unimproved lots.

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[11] Wootan and Meuth, "Economic Impact Study, Temple, Texas"; Buffington and Meuth, "Economic Impact Restudy, Temple, Texas"; Buffington, "Economic Impact Study, Huntsville, Texas"; "Economic Impact Study, Conroe, Texas," "Economic Impact Study, Waxahachie, Texas."

TABLE 11. CHANGES IN LAND VALUES IN UNIMPROVED AREAS ALONG BYPASS ROUTES

Study Area	Study Period (b)	Average price per acre ($) (a)			Percent Increase		Highway Influence	
		Abutting	Non-Abutting	Control Area	Study Area	Control Area	$/acre	percent
Temple (I)	1941-48	58	58	57				
	1949-54	440	91	112	168	45	733	1227
	1955-57	920	214	108	430	-4		
Temple (II)	1943-48	91	91	98				
	1949-54	921	549	136	531	39	2331	2562
	1958-61	3779	2062	143	2601	0		
Waxahachie	1951-55	172	243	109				
	1956-58	1123	429	142	290	30	590	288
	1958-62	847	833	141	20	-1		
Conroe	1952-58	1231	497	793				
	1959-62	500	436	930	3	17	702	95
	1963-65	1658	684	698	77	-25		
Huntsville	1950-54	1197	891	400				
	1955-59	8127	1460	487	192	22	2376	253
	1960-64	7205	1038	497	26	-2		

[a] All prices adjusted to Labor Statistics Consumer Price Index, 1947-49 - 100.

[b] The first period for each study is the "before" period, the second is the "construction" period, and the third is the "after" period.

In order to determine the effect on land values with proximity to the highway facility, the sales were classified as abutting and non-abutting. As shown in Table 11, the unimproved properties abutting the highway right of way received a much greater highway influence than nonabutting properties. As there were frontage roads along most of the bypass routes, this difference between abutting and nonabutting properties could be caused by the direct access to the frontage road for abutting properties.

Rural Areas. In most cases, studies of highway impact in rural areas tend to support the view that there is an increase in land value due to highway

construction or improvement.[12] However, the results are not uniform, and the causes of changes in land value are not readily identifiable.

One study of the influence of highway on rural land values in the United States does tend to show that land value of farms varies with the quality of the road, although distance to nearest trading center appears to be the most significant factor.[13] Farms were classified according to both the surface of the road which served them (hard-surfaced, gravel, and dirt) and the quality of the land. Regardless of land quality the sales price per acre increased with better quality of service road.

Analysis of the effect of interstate routes on land values in rural areas is complicated by accompanying changes in land use. One study in North Carolina found an increase in land value along three different interstate routes ranging from 3.6 to 133 percent.[14] It is clear from the study that land value varies greatly with land use, but the increase in land value for some categories of land use showed an even greater variance than that of all categories combined. Thus, no clear pattern emerges that might explain the increase in land value according to land use alone.

When results from different study areas are compared, no hard and fast inferences about the effect of highways on rural land values may be drawn. For example, the North Carolina study indicated an increase in the price of

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[12] See, for example, P. D. Cribbins, W. T. Hill, and H. O. Seagraves, "Economic Impact of Selected Sections of Interstate Routes on Land Value and Use," Highway Research Record 75, 1967, pp. 1-31; G. E. Bardwell and P. R. Merry, "Measuring the Economic Impact of a Limited Access Highway on Communities, Land Use, and Land Value," Bulletin 268, Highway Research Board, 1960, pp.37-73; Buffington, "Economic Impact Study, Rural Area East of Houston, Texas," and "Economic Impact Study, Chambers County, Texas."

[13] T. W. Longley and B. T. Goley, "A Statistical Evaluation of the Influence of Highways on Rural Land Values in the United States, Bulletin 327, Highway Research Board, 1962, pp. 21-55.

[14] Cribbins, et al., op. cit., pp. 18-22.

farm land ranging from 21 to 198 percent, while three studies from Texas found no significant increase in farm land value along interstate routes.[15]

Impact on Business Activity

As it has been pointed out, land value varies with land use. Apparently there also is a relationship between the anticipated net return of business activity and what an investor is willing to pay for a special site. Some types of businesses are to a high degree dependent upon good access; thus it is reasonable to think that transportation facilities have a great influence on these business activities.

Interchange Areas. The study of interchanges along I-94 in Michigan analyzes service station gallonage at full interchanges.[16] The gallonage is averaged within each interchange classification (major city, secondary city, small town, and rural area). A statistical analysis was made to test whether there was a significant difference in business success between one interchange classification and the other. The major city interchange stands out from all other classes with a pumpage almost double the average of the others. A significant difference was not found between the other classes, even though the average pumpage for service stations in small towns was a little higher than the average at secondary city and rural interchanges.

To find the influence of proximity to the highway, the difference in pumpage for service stations within or outside a distance of 400 feet from the freeway was tested. The difference was found to be statistically significant and sharply focuses on benefits derived from the freeway.

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[15] Meuth, "Right of Way Effects of Controlled Access Type Highways on a Ranching Area in Madison County, Texas"; Meuth and Buffington, "Right of Way Effects of Controlled Access Type Highway on a Farming Area in Ellis County, Texas"; Meuth, "Right of Way Effects of Controlled Access Type Highway on a Farming Area in Colorado and Fayette Counties, Texas."

[16] Ashley and Berard, "Interchange Development Along 180 Miles of I-94."

Bypass Routes. Several studies from Texas investigate the influence on business activities of new bypass routes.[17] In these studies the average of the gross sales for different business activities is calculated for different time periods. To provide a truer picture of the net effect, some of the studies include information on businesses located along both the new facility and the old route. In other cases, comparison is made between business activity along the bypass route and that of the local area and/or the state. The result is summarized in Table 12, page 30.

Traffic-serving businesses, such as service stations, motels, etc., are separated from non-traffic serving businesses. However, it is difficult to draw any general tendency from the table. As can be seen in the table the variation is less for non-traffic service businesses than for traffic-serving businesses. Also, the non-traffic services in all but a few cases show an increase in annual gross sales, while many traffic-serving activities experienced great decreases. The information in this table indicates that traffic-serving businesses are more affected by the highway facility than are other types of operations, but the reports do not give enough information about the design of the highway facility or about community-related factors to explain why, when both old and new routes are considered, service stations and motels in some areas experienced an increase in gross sales while those in other areas showed a decrease.

Rural Areas. A study of businesses along secondary roads in Kentucky may indicate the effect of highway improvement in rural areas.[18] Two periods, 1938-50 and 1955-60, were studied. The total number of businesses in the area increased, even though there was a decrease in the number of "open-country" stores. Analysis of the data shows that improvement of intercounty routes and of intracounty "collectors" appears to be of primary benefit in effecting market adjustments.

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[17] Buffington and Meuth, "Economic Impact Restudy, Temple, Texas"; Buffington, "Economic Impact Study, Rural Area East of Houston, Texas"; "Economic Impact Study, Huntsville, Texas; "Economic Impact Study, Conroe, Texas"; and "Economic Impact Study, Waxahachie, Texas."

[18] R. H. Stroup and L. A. Vargha, "Economic Impact of Secondary Road Improvements," Highway Research Record No. 16, Highway Research Board, 1963, pp. 1-13.

TABLE 12. PERCENT CHANGE IN ANNUAL GROSS SALES OF BUSINESSES ALONG BYPASS ROUTES

Study Area	Before and After Study Periods (a)	Traffic Serving				Non-Traffic Serving					Total % Change of Gorss Sales For All Businesses
		O-Old route B-Both routes	Service Stations	Food Service	Motels	Total	Grocery	Services	Miscellaneous	Total	
Temple (II)	54,57	O	10.6	-19.1	-54.4	-15.3	5.5	NG	19.2	8.2	4.7
	54,57	B	NG[b]	NG	NG	NG	NG	NG	NG	NG	7.7
Bell County	54,57	-	NG	NG	NG	NG	NG	NG	NG	NG	12.6
State of Texas	54,57	-	NG	NG	NG	NG	NG	NG	NG	NG	19.5
Waxahachie	58,62	B	-18.7	0.8	43.3	-13.5[c]	NG	NG	NG	NG	3.5[d]
	58,62	O	NG	NG	NG	NG	-19.4	33.8	25.0	10.1	NG
Total City W.	58,62	-	NG	NG	NG	NG	NG	NG	NG	NG	13.1
State of Texas	58,62	-	NG	NG	NG	NG	NG	NG	NG	NG	17.8
Rural, East of Houston	58,62	-	NG	NG	NG	6.7	- 7.2	NG	36.7	-1.0	0.5
Conroe	62,65	O[e]	-10.0	-14.0	17.0	- 9.0	6.0	80.0	-3.0	25.0	9.0
	62,65	B	-20.0	-15.0	17.0	-17.0	1.0	63.0	171.0	53.0	NG
Huntsville	58,64	O[e]	25.0	6.4	-23.7	13.4	-21.5	15.3	50.0	20.9	19.1
	58,64	O	- 8.5	23.3	19.3	2.4	NG	NG	NG	NG	NG
	58,64	B	19.1	47.1	48.7	29.0	85.0	97.0	43.0	58.1	NG
Merkel	58,62	B	NG	NG	NG	64.7	NG	NG	NG	24.9	NG
Total City M.	58,62	-	55.1	70.9	-66.6	53.3	7.2	32.7	4.5	13.1	18.9

[a] The study periods are designated by the last year of each period.

[b] This information was not gathered.

[c] Figures from 36 businesses.

[d] Figures from all 73 businesses.

[e] Figures only from firms operating both first and last year in a period.

Impact on Industrial Location and Manufacturing Growth

An objective of two of the studies reviewed was to determine which factors are important to industry in making plant location decisions. One of the studies included interviews of a small number of the owners of industrial firms currently located on free access roads.[19] All of the firms but one were primarily dependent upon trucks to transport their final product, and all of the firms, with one exception, felt that location in close proximity to a major highway was necessary. However, little priority was given to specific types of highway facilities. If the road was paved and in good condition, it was judged adequate. Advertising benefits resulting from location received little consideration by the owners. For most, this factor was viewed as providing a possible extra benefit rather than as being a requirement. However, some concern for the value of the advertising benefits of a location was shown by firms serving consumer as opposed to industrial markets.

Another study analyzes a nationwide questionnaire survey of manufacturing, wholesale and warehousing establishments.[20] Each of the firms had made one or more moves during the period 1955-59.

Survey findings indicated that, of 13 different plant location factors included in the questionnaire, the most frequently mentioned concern was proximity to good highways. On the average the next four most important factors were, in this order, abundant labor supply, availability of suitable land, proximity to markets, and rail service. However, different establishments ranked the rail service differently in importance from first to eleventh place. Industries giving emphasis to both highway proximity and rail service are printing and publishing, wholesale trade, fabricated metal products, furniture and warehousing.

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[19] Donald J. Bowersox, "Influence of Highways on Selection of Six Industrial Locations," Bulletin 268, Highway Research Board, 1960, pp. 13-28.

[20] Edward V. Kiley, "Highways as a Factor in Industrial Location," Highway Research Record No. 75, Highway Research Board, 1965, pp. 48-52.

In two highway impact studies (bypass studies), operators of retail businesses reported advantages and disadvantages of the construction of a new highway facility.[21] The results from both studies are quite similar. There was a general agreement by both traffic-serving businesses and others that the new bypass route relieved traffic problems. As Table 13 shows, non-traffic serving businesses reported more advantages of the new facility than did traffic serving businesses (this is in harmony with reported business activity in Conroe according to Table 12).

TABLE 13. ADVANTAGES AND DISADVANTAGES OF A BYPASS ROUTE AS REPORTED BY OWNERS OF RETAIL BUSINESSES

Item	Number of Businesses	
	Traffic Serving	Nontraffic Serving
Advantages:		
Relieved traffic problem	22	24
Helped personal business	4	10
Helped all except traffic serving	9	3
Helped all businesses	3	4
Other	8	10
Disadvantages:		
Failed to relieve traffic problem	0	1
Hurt personal business	16	3
Hurt only traffic serving	0	8
Hurt all businesses	9	2
Others	3	7

One of the few studies investigating air, rail and water transportation in addition to highways deals with the effect of transportation on urban manufacturing growth.[22] One hundred and six different city pairs (freeway located

[21] Buffington, "Economic Impact Study, Conroe, Texas"; and, "Economic Impact Study, Waxahachie, Texas."

[22] Leonhard F. Wheat, "The Effect of Modern Highways on Urban Manufacturing Growth," Highway Research Record No. 277, Highway Research Board, 1969, pp. 9-24.

cities matched by similar non-freeway located cities) all over the nation are included.

In short, the conclusions and observations developed by this study are:

(1) Modern highways significantly affect manufacturing growth, but not in all situations. Freeway cities grew faster only in regions where traffic flow along regular highways is seriously impeded.

(2) Freeway cities with populations greater than 16,000 grew faster than corresponding non-freeway cities.

(3) Cities with airline connections grew significantly faster, particularly in the South and West, for pairs above 19,000 population. This suggests that industry is attracted especially to freeway cities when there is concomitant air service.

(4) Cities with poor rail service might experience "catch-up growth" with the advent of a freeway, the road becoming a substitute for rail service.

(5) For the five waterway pairs included in the study, both freeway and non-freeway cities showed lower employment rates.

(6) The relationship between growth and distance to the freeway is described by a normal probability curve peaking at 0 miles with a standard deviation of roughly five miles. Benefits of growth do not usually accrue to cities located more than about ten miles from the nearest freeway.

(7) Freeways probably stimulate existing industry as well as attract new plants.

Impact on Social Characteristics

The literature on this subject is rather incomplete. However, there are a few studies concerned with the social impact of interurban transportation links on rural communities.[23] Although detailed information about social impact does exist for urban areas, it is questionable whether such data can

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[23] A. S. Lang and M. Wohl, "Evaluation of Highway Impact," Bulletin 268, Highway Research Board, 1960, pp. 105-119; U. S. Department of Transportation, "Benefits of Interstate Highways," Federal Highway Administration, Department of Transportation, June 1970, pp. 1-32; Floyd I. Thiel, "Social Effects of Modern Highway Transportation," Bulletin 327, Highway Research Board, 1962, pp. 1-20; H. Kirk Dansereau, "Five Years of Highway Research: A Sociological Perspective," Highway Research Record No. 75, Highway Research Board, 1965, p. 76-81.

be of use in the study of rural areas because of the basic differences in the profile and composition of rural and urban communities.[24]

Most studies dealing with social impact have shown positive consequences resulting from highway construction. The Federal Highway Administration reports that the Interstate Highway Program received broad community support because of reduced congestion of local streets, reduced noise and air pollution, better access to recreational facilities, and higher economic levels for the town's businesses. For rural communities, in particular, they have served to upgrade primary and secondary educational facilities, improved vocational training possibilities, and made medical care more accessible.[25] Other advantages reported include increased accessibility to shopping and recreational facilities as well as to church, lodge, and organized farm-related functions.[26]

The best discussion found so far has been presented by Dansereau.[27] In his study of rural/suburban communities he found that when a highway was introduced into an area, certain results occurred. The population increased because of the inward migration of younger and higher-income people, thus, raising the standard of living. This population increase took place more rapidly in communities located on arteries of the highway than in those not located on arteries. In the areas studied, levels of living rose visibly with the introduction of new manufacturing concerns (attracted, in part, by the new highway). It was further found that towns which were located nearer highways were more likely to develop a comprehensive community plan. However, most of the users of the highway were those who were in higher occupational, income, and educational groups, who were active in organizations, and who were newcomers to the area.

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[24] R. J. Bouchard and E. L. Lehr and M. J. Redding and G. R. Thomas, "Techniques for Considering Social, Economic, and Environmental Factors in Planning Transportation Systems," Highway Research Record No. 410, Highway Research Board, 1972, p. 1-7; E. A. Beimborn and B. P. Nedwek and C. R. Ryan, "An Evaluation of the Feasibility of Social Diagnostic Techniques in the Transportation Planning Process," Highway Research Record No. 410, Highway Research Board, 1972, p. 8-23.

[25] U. S. Department of Transportation, "Benefits of Interstate Highways."

[26] Thiel, "Social Effects of Modern Highway Transportation."

[27] Dansereau, "Five Years of Highway Research: A Sociological Perspective."

There is a relation between impact on land use and social impact. In one study, it was found that a highway and its bypass routes have a significant effect on a community's growth pattern.[28] This particular study also points up the difficulty of separating studies of social "impact" from the evaluation process. The article concludes that, in order to allow "orderly" growth, a highway should be located at a considerable distance from the community's "prime growth center."

The general view that interurban highways increase the mobility of the rural population deserves comment here. Modern freeways and the private automobile have shortened travel time drastically. Thus people can commute over longer distances in the same amount of time. This means greater opportunity of employment in metropolitan areas for people in outlying communities, but it also may result in other, less desirable social and economic change in these same communities. Thus there is a need to determine the net change in the socio-economic structure of rural communities affected by alterations in the interurban transportation system.

General Community Response

Little has been done in investigating community response to highway improvement. Even though some of the fundamental effects of highway improvement upon land use, land value, business activities and location of industry are known, the resulting effect upon the development of communities with different potentials for response has not been determined.

This lack of knowledge, to choose one example, led to the effort to reverse economic trends in eastern Connecticut by means of a highway system, the Connecticut Turnpike.[29] This example seems to illustrate that merely providing a highway system does not necessarily mean an economic boom for the adjacent communities. Highways can be a stimulus for change, but the response to this stimulus depends on the capacity for change existing in the areas to

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[28] Louis A. Vargha, "Highway Bypasses, Natural Barriers and Community Growth in Michigan," Bulletin 268, Highway Research Board, 1960, p. 29-36.

[29] W. C. McKain, "Community Response to Highway Improvement," Highway Research Record No. 96, Highway Research Board, 1965, pp. 19-23.

be served. What the change will be depends greatly on both economic and human responses.

Walter C. McKain states:[30]

> Highways can furnish only the external stimulus for change. The response made to this stimulus depends on the capacity for change existing in the areas to be served. The presence of other resources, the availability of community leaders, and a plan for action are needed components for social action. Depending on the availability of these other elements, a new road can be either a minor irritant or a positive force for change. The ingredients for community development go far beyond adequate or even superior transportation.

The effect of the turnpike on the individual communities in eastern Connecticut varied. Retail sales, as measured by tax receipts, increased 54 percent in an eight year period for the entire area served by the Connecticut Turnpike. In four of the towns, the revenue increased by 300 percent or more, in three other towns the increase was less than 35 percent, and in two towns there was actually a decline. Although manufacturing employment increased 42 percent for the entire area, in nine towns the number of jobs declined. Real estate values rose in every town, but not uniformly in the entire area.

One plausible reason for the difference in development may be attributed to differences in the resources of separate communities. The potential for development is a function of the interaction of natural and human resources, and thus a given community will respond to change in accordance with its own potential. For example, a textile mill in one community is said to have created a group of workers who do not readily improve their skills. More generally, some communities tended to resist change and adopted a crisis approach to social action.[31]

EFFECTS OF OTHER TRANSPORTATION MODES

Effect of Airports

Previous studies of the effect of airports on rural communities have shown that air transport can play an important role in promoting community

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[30] W. C. McKain, "Community Response to Highway Improvement," Highway Research Record No. 96, Highway Research Board, 1965, pp. 19-23.

[31] Ibid.

and regional growth.[32] However, no body of literature exists comparable to that of highway impact studies.

A study from Texas Aeronautic Commission gives the results of an attitude survey among towns and communities in Texas.[33] The report states that towns of 2,000 - 5,000 population are most apt to be aware of the importance of the need for an adequate airport to attract new business and to maintain and enhance its position in the struggle for economic growth. Small communities placed considerable emphasis on their proximity to adequate airport facilities in adjacent metropolitan areas. Interest in commercial service began when a city reached a population of 24,000 or more.

A nationwide study of cities located along freeways indicates that for places with a population of more than 19,000, cities with air transportation grew faster than cities without air transportation.[34] This was particularly the case for cities located in the South and West. Possibly industry is especially attracted to cities with air facilities in areas with significant distance between one city and another and no developed public interurban transportation system.

Rail or Bus services.

Wheat points to the fact that the effect of highway improvement to some degree may be influenced by existing rail service.[35] Cities with poor rail service might experience "catch-up-growth" with the advent of being connected to the freeway network, with the freeway becoming a substitute for rail. No report reviewed deals with the effect of decreased rail services, and no

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[32]For a review of studies of the effect of air transport on regional and community development, see the "Joint DOT-NASA Civil Aviation Research and Development Policy Study," Supporting Papers (DOT TST 10-5/NASA SP-266), Department of Transportation and National Aeronautics and Space Administration, Washington, D.C., March, 1971, pp. 7/7 - 7/9.

[33]Texas Aeronautic Commission, "Importance of a Modern Airport," Austin, Texas, 1965.

[34]Stroup and Vargha, "Economic Impact of Secondary Road Improvements."

[35]Ibid.

report has been found which explains the importance of the presence of public interurban bus transportation.

MODELING OF HIGHWAY IMPACT

The data and the conclusions from the highway impact studies reviewed to date do not provide predictive tools for the transportation planner. Conclusions are often confirmations of the obvious (e.g., that traffic-serving businesses are the first to develop at interchange areas), or else they are limited to the specific region studied and thus provide little that may be used to formulate hypotheses about the general nature of highway improvement impact in rural areas or on small communities. No study can rise above the limitations of the methodology upon which it is based, and most highway impact studies have been subjected to severe criticisms on methodological grounds.[36] Before proceeding to a review of methodology, however, we will consider the relatively few efforts to model the impact of highway improvement. The small number of such efforts is probably explained by the complex cause/effect relationship between highway improvement and community characteristics and also by the fact that many important variables are qualitative and not readily quantifiable. As modeling efforts in most cases depend upon obtaining information for previous years from local records, available data may limit the number of different factors included in the analysis.

Different models may be created according to the purpose of particular highway impact studies. So far only models of land development and land value have been reviewed.

Land Development

One important effect on land development in an interchange is increased traffic volumes, possibly producing capacity problems on entrance or exit ramps. The study of interchanges along Interstates in Indiana evaluates the

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[36] See Charles Rivers Associates, Inc., "Measurement of the Effects of Transportation Changes," National Technical Information Service Report PB 213 491 (September, 1972).

[37] Fabbroni, "Land Use Development at Interstate Interchanges in Indiana."

ability of a model to predict magnitude of road user developments at an interchange.

The interchange development is expressed as "weighted development"; different land uses are given different weights, since they have different traffic generation rates. The following weights are used:

Service stations	1
Restaurants	1
Motels (small or large chain)	1/2 - 1 1/2
Truck stops	4
Neighborhood shopping centers	3
Regional shopping centers	6
Service stations combined with short order restaurants	1 1/2

"Total weighted development" is the weighted sum of the establishments at the interchange. The final regression model gives the following expression:

$$\begin{aligned}\text{Weighted development} &= 2.016 \\ &+ 1.18 \times (\text{ramp volume}) \times 10^{-3} \\ &- 0.5897 \times (\text{population within 20 miles}) \times 10^{-4} \\ &- 2.49069 \times (\text{interchange age}) \times 10^{-1} \\ &- 0.84518 \times (\text{economic index}) \times 10^{-3} \\ &-25.18036 \frac{(\text{economic index})}{(\text{population index})}\end{aligned}$$

The population index is an expression of population in the highway corridor divided by distance from the interchange under consideration. The economic index expresses the influence of parallel routes.

Standard error of estimate turned out to be 13.87, and $R^2 = 0.5989$. The above model was found to be the best that could be developed without adding extensive additional data. In addition to the low R^2 achieved, the study may be questioned on the basis of whether "weighted development" is an appropriate measure for interchange development. One may also question the use of the two theoretical variable indices. To refine the model further, more factors describing the transportation and the community probably would have to be considered.

Land Values

Another study from Indiana was undertaken to develop a technique for predicting the impact of highway improvement on the value of adjacent land parcels.[38] Two different sets of data, one from Indiana and another from Florida, were used to run a regression analysis of the change in land value as a function of different variables.

The predictor variables included in this study were:

(1) Parcel size (in acres)

(2) Time elapsed between completion of highway improvement and sale of parcel (in months)

(3) Type of highway improvement (interstate, primary or secondary highway)

(4) Type of land use (residential, commercial, agricultural or vacant)

(5) Type of area (urban, urban fringe or rural)

(6) Type of access control (full, partial or none).

Each type within variables three to six was treated as a dummy variable, which assumed a value of one or zero depending on whether or not it was observed for the parcel in question.

All but four of the 100 parcels in the Florida data included interstate highways with full access control. The regression analysis showed that the variables included in the regression equations gave an R^2 varying from 0.24 to 0.46 depending upon the form of the regression equation. Consequently, at most only 46% of the change in land values could be explained by the above mentioned variables.

The Indiana data (33 parcels) indicated a much stronger relation between change in land values and the independent variables. The regression analysis gave an $R^2 = 0.87$. Some classes of the variables contained only a few observations, and the regression equation is consequently not presented as a reliable predictive model. Figure 2 (page 41) shows the relative importance

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[38] Edward I. Isibor, "Modeling the Impact of Highway Improvements on the Value of Adjacent Land Parcels," Joint Highway Research Project C-36-64G, Purdue University, December, 1969.

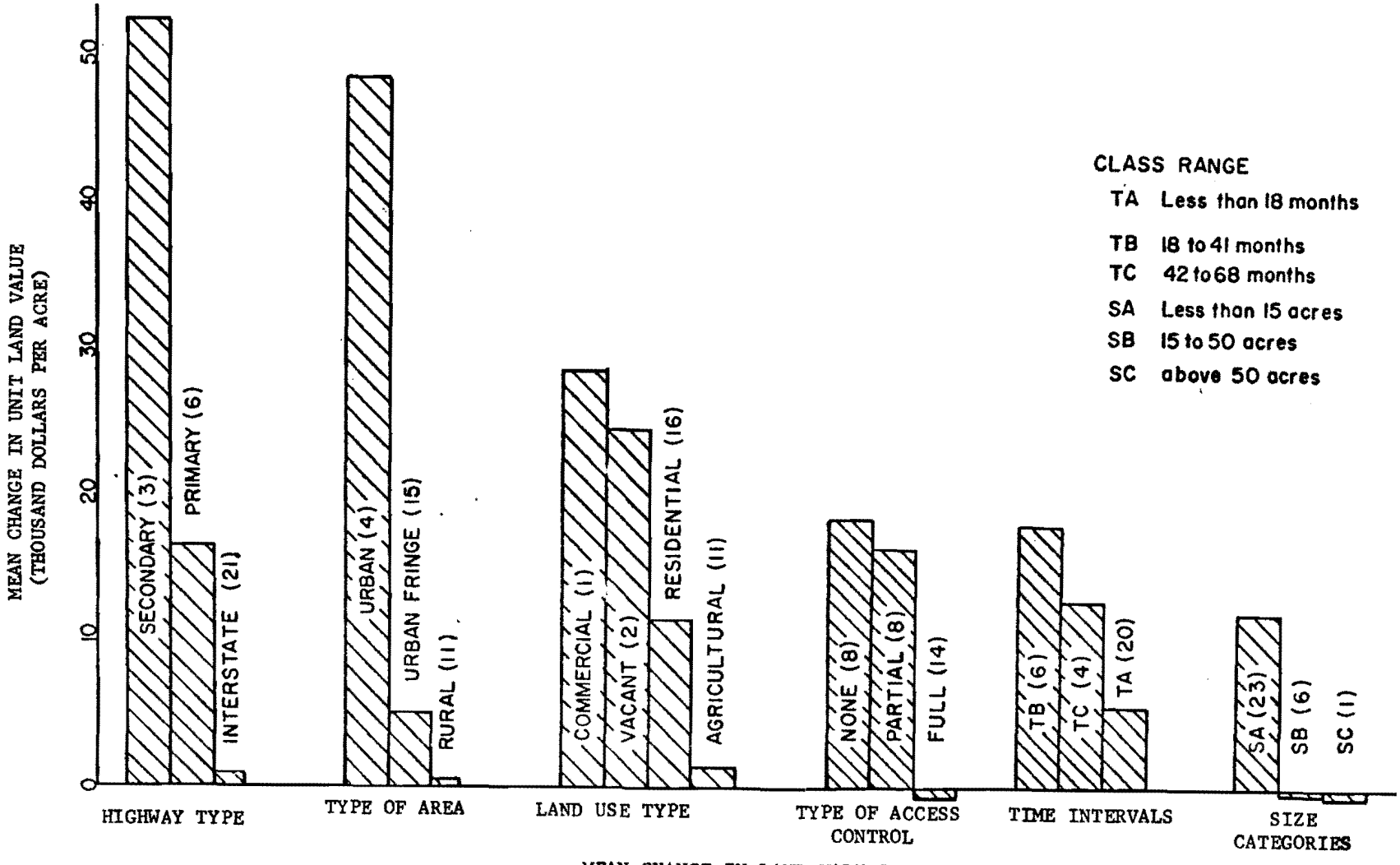

Figure 2

VARIATION IN LAND VALUE
BY TYPE OF VARIABLES

of the independent variables used in the regression analysis. According to the analysis, the type of highway improvement is the most important variable, followed by type of area, land use type, type of access control, time elapsed after highway improvement, and size of parcel.

As can also be seen, construction of a secondary or primary road appears to cause greater changes in land values than does construction of an interstate highway. The changes in land value are greatest in urban areas. Without regard to type of area, commercial and vacant land both show a greater increase in land value than that devoted to residential or agricultural uses. Full access control can result in a decrease in land value. Parcels smaller than 15 acres evidently increased more in land value than did large parcels.

One should have in mind that this study was limited to "remainder" parcels which sold some time after the highway improvement. No information is available about which factors influence an owner's decision to sell or not to sell a remainder parcel. The model, consequently, is not of general use for predicting the value of parcels adjacent to or in the proximity of highway improvement.

A more general modeling effort of land values was done in North Carolina.[39] The study included interstate construction in different rural areas. The dependent variable was land value, and the independent variables included size of parcel, year of sale, land use, distance to right-of-way, distance to business district, distance to interstate access, etc. The most important single variable influencing land value was found to be the size of the parcel; the smaller the parcel, the higher the unit price. For specific land uses, certain other variables showed high simple correlation with unit price, but these correlations vanished when multiple regression analysis was used. This indicates a relationship between the independent variables rather than between the dependent and the independent variables. No information about R^2 for this analysis was given, and therefore the degree to which variation in land value was explained by the independent variables is unknown.

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[39] Cribbins, et al., "Economic Impact of Selected Sections of Interstate Routes on Land Value and Use."

Modeling efforts reviewed to date deal primarily with land value as the dependent variable. In this area, the evident need is the development and refinement of indices for the independent variables in order to isolate highway-related from non-highway-related factors influencing land value.

Results from different studies are not always comparable, as might be expected given the different modeling techniques and the different indices developed for the expression of the independent variables.

CHAPTER III. ANALYSIS OF THE PREVIOUS STUDIES

III. ANALYSIS OF THE PREVIOUS STUDIES

Most of the studies reviewed concentrate on impact from highway improvement. Even though the private automobile is the major mode of transportation today, these studies cannot reveal any information about the consequences of changes in air, rail or bus services. The studies show clearly that highway improvement has a significant impact, and usually a positive impact, on the areas along the facility, but not one of the studies reviewed evaluates the consequences of reduction in transportation service, as has been the case in most areas with rail service during the last two decades.

The previous highway impact studies provide a great deal of information, but their limitations should be noted. Many studies are directed more towards describing an impact, and the magnitude of the impact, than toward examining the cause/effect relationship. These studies are of value in showing the benefits of public investment in highway improvement, and they justify the spending of public funds in terms of "non-highway user" cost/benefit. However, they are of less value as a tool for highway or community planners since they cannot be used to predict the future impact of changes in the highway system in a particular community. All of the studies support general observations about the development of adjacent land, the increase in business activity and increasing land values close to the new facility, but few of them are designed to reveal the impact on the community as a whole.

The fact that each community has its own characteristic in terms of economic and human resources, geographical location, etc., makes it difficult to use the highway impact observed in one community to forecast the effect of highway improvement in another community. A forecast would be possible only where general community characteristics are included in the analysis, but unfortunately this is not usually the case.

In addition to these general limitations, previous highway impact studies are subject to criticism on more specific grounds, depending upon the particular methodology used in the research. Consequently, it is important to examine the advantages and limitations inherent in each of the five categories of study methodology before recommending a strategy for future research.

The Before and After Technique

This technique is the most commonly used; it is used either singly or in combination with other techniques in all studies dealing with changes in highway facilities. The main advantages of this approach are, first, that it is simple to apply and, second, that it is easy to understand. The technique measures the value of some of the characteristics of an area before and then after the highway improvement; the difference is said to be the effect of the improvement. Consequently, the only quantity measured is the change in value between one time period and another. The greatest disadvantage is very obvious: this technique cannot relate the measured effect to any specific cause. Since in most cases there will be a span of 3 - 5 years between the before and the after period, many factors other than highway improvement are likely to influence the study area. Thus, this technique cannot determine whether an effect is, or is not, caused by the road improvement. In an attempt to isolate highway effect, the survey- control area technique is often used with the before-after technique. However, as will be shown in the next section, the survey - control area technique is not itself a sufficient way of revealing the scope of the highway impact.

Most studies are conducted in the after period. This may cause difficulties in determining or measuring the nature of the study area in the before period. The only way to avoid this shortcoming is to select an area where the necessary information on the before period is available, thus considerably limiting the number of areas which may be studied. Even assuming that sufficient information from the study area is available, there still remains a major disadvantage to the before and after technique. For each characteristic to be measured, only one value can be assigned for each of the two time periods. The before period, theoretically, has only one defined limit, usually the date on which construction of the improvement was begun; the after period is also defined by narrow limits, usually the period between completion of the highway facility and the date of the study itself. In practice the average length of the before period is approximately only two years; the length of the after period usually varies from two to four years. (In reality, the length of the "before" period is undefinable because it is not known when knowledge of a proposed highway improvement begins to influence the development of an area.)

Figure 3, p. 48, shows the possible pattern of a single response, in this case land value, to changes in the highway system. As can be seen, the before-after technique reveals no information about the trend in the before or the after period. The measured effect of the improvement will be the same regardless of the trend during the time preceeding the change in the highway facility. It is reasonable to say that the effect of the improvement is greater in cases where an existing "downward" trend is reversed than in the cases where the trend is already "upward," even though the measured effect in terms of a value for community response is the same. Consequently, it would be more logical to measure the effect in terms of the difference between the response to actual transportation improvement and a projection of the before-trend (assuming that no improvement had occurred). This situation is represented in Figure 4, p. 49. The total community impact over a time period would be the area between the two curves. Different phases in the improvement planning and implementation process may have different effects on community response (also indicated in Figure 4). What the general shape of such a curve would be, assuming that the effect caused by the highway system development could be isolated for each period, is not known.

It is assumed that general public knowledge of the project, purchase of right of way and so on, will have an influence on the community response, even if not of the same magnitude as the acutal construction of the improvement. Since events other than construction usually fall outside the scope of the before and the after study periods, their effect cannot be determined.

The Survey-Control Area Technique

This is the most common technique used to isolate highway impact. It has been frequently used to study the effect on land values in an area adjacent to a new highway facility (the survey area). To separate the effect of non-highway related factors from those related to the highway, a control area, similar to the survey area, is selected. This control area is ideally chosen far enough from the highway to have been unaffected by the highway facility.

In theory, the survey area and the control area would have to be exactly alike in all respects during the period just prior to the highway improvement. Also, the factors affecting development in the two areas should be the same,

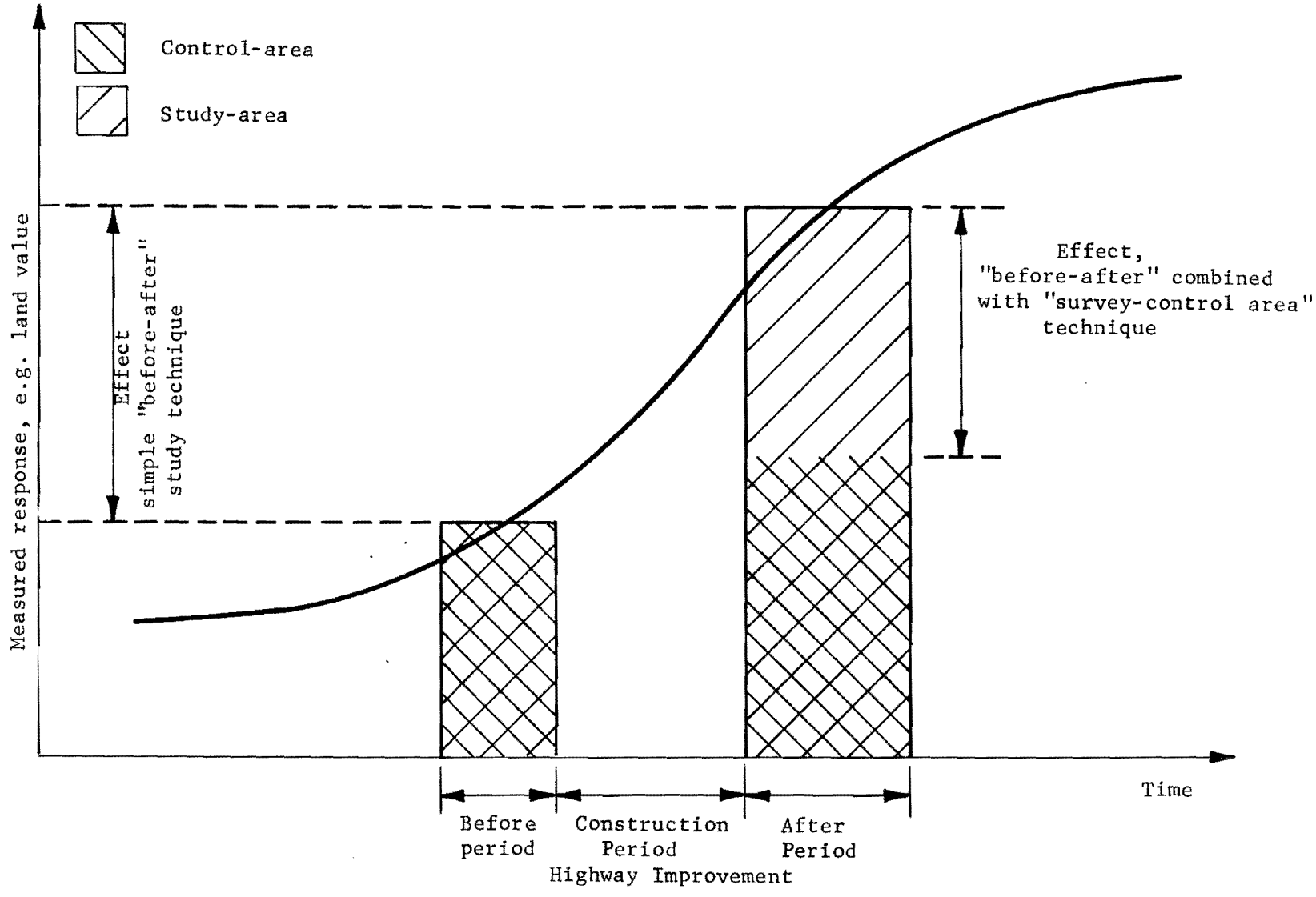


Figure 3

BEFORE-AFTER STUDY TECHNIQUE

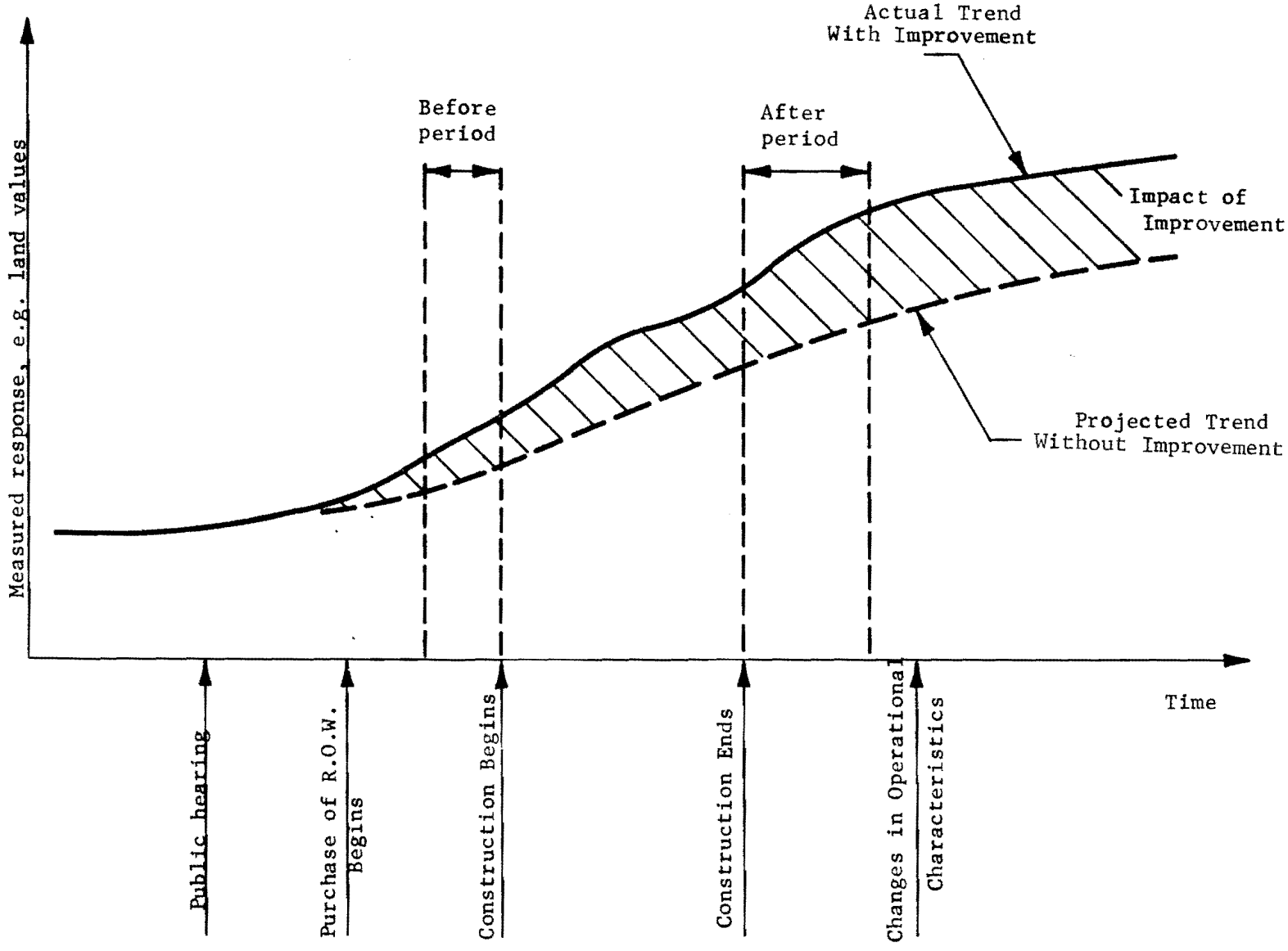


Figure 4

POSSIBLE EFFECT OF DIFFERENT PHASES IN HIGHWAY IMPROVEMENT

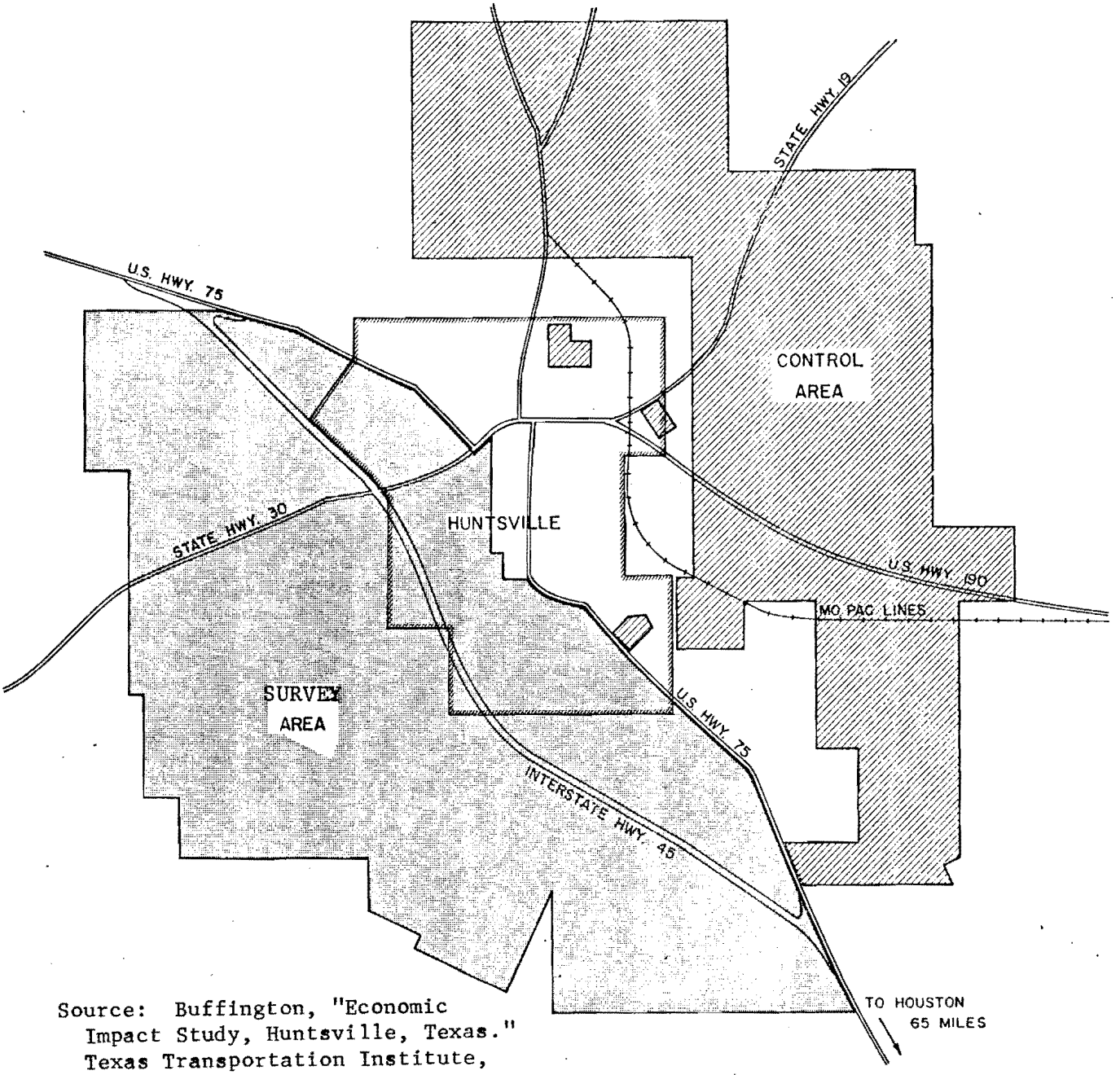
except for the highway improvement. These requirements are hard to meet, as the spatial limits or distribution of the highway impact are not known in advance, and it is difficult to gather information relating to all non-highway related factors. For example, certain social groups frequently control certain areas of the community, and thus economic activity may be linked to a limited area, and land development may be strongly influenced by the local power-structure. For these and other reasons, it may not be possible to find an ideal control area.

In practice, the survey-control area approach does not give any information about the spatial distribution of the impact unless the survey area is divided into sectors, bands, etc. Usually, this has not been done. Figure 5, p. 51, shows survey and control areas as selected in an actual study. It is obvious that the effect of the different factors will not be evenly distributed over the two areas. When the average value for each area is used, the character of this spatial distribution is lost, and thus the interpretation of any results of the study would be extremely limited.

The same figure also illustrates that these two areas, as chosen, could not be used to describe the effect of changes in the total transportation system if the changes were more extensive than merely the construction of the bypass route. Changes in rail or air service and alterations in local traffic conditions could affect the survey area and the control area differently, making it impossible to measure the total effect of changes in the transportation system.

While the survey-control area approach has offered an apparently scientific way to determine impact in a limited survey area, providing the requirements for the selection of a control area can be met, the method cannot be used to study the effect on the entire community. The community effect will include the effect in both the survey and the control areas; consequently, the "zero" effect in the control area, as well as all degrees of effect up to the maximum in the areas adjacent to the new highway facility, are of interest. This is illustrated in Figure 6, p. 52. The average community effect depends on both magnitude and spatial distribution of the effect on the entire community area.

In a small community it probably would be difficult to find any control area not influenced by major changes in the transportation system. A new



Source: Buffington, "Economic Impact Study, Huntsville, Texas." Texas Transportation Institute, Bulletin 38, 1967.

A map showing the relationship of the study and control areas to Huntsville and the transportation facilities in 1964.

Figure 5

EXAMPLE OF SELECTED SURVEY AND CONTROL AREAS

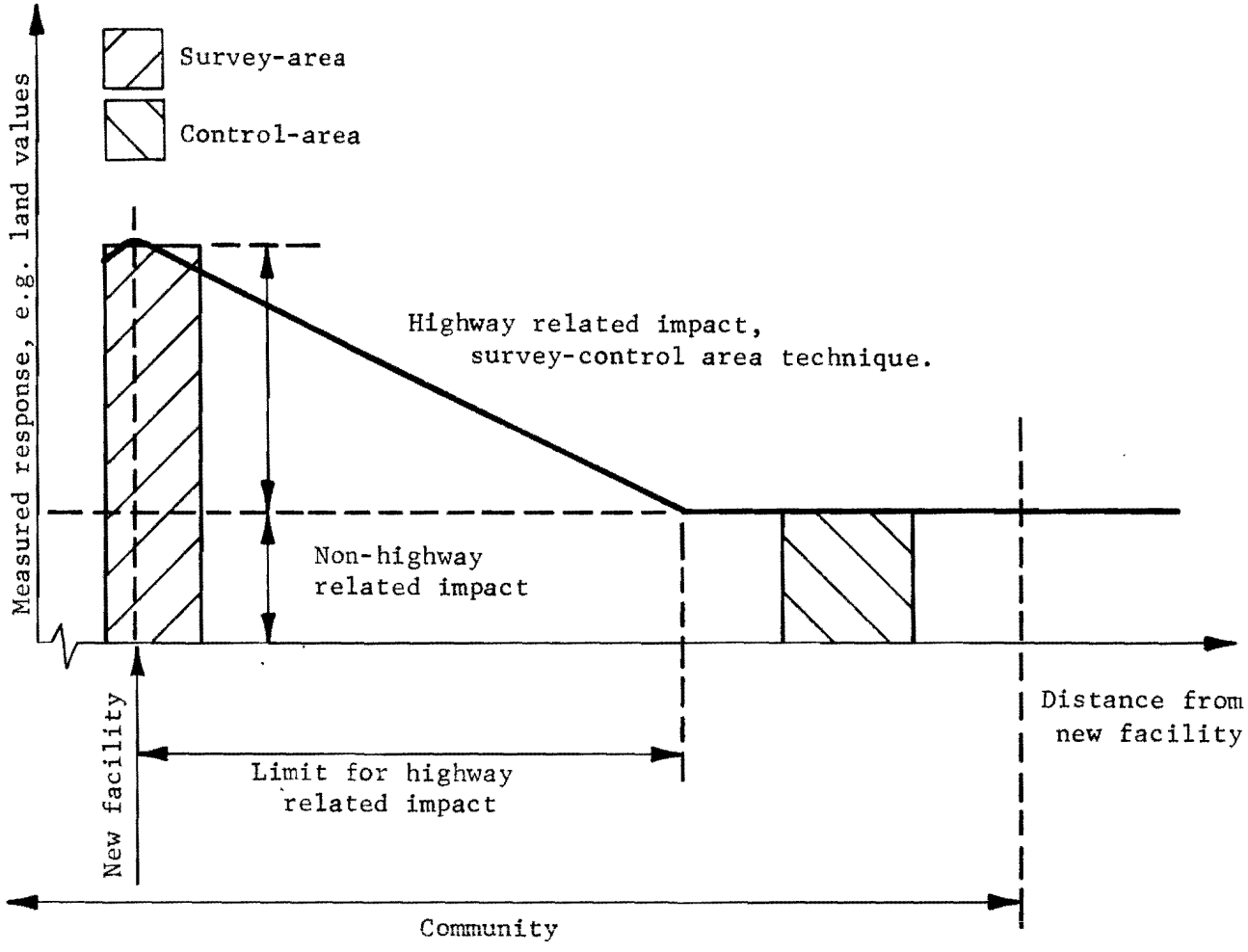


Figure 6

SURVEY-CONTROL AREA STUDY TECHNIQUE

facility will possibly cause new activities to be established, but it might also cause already established activities to move from their old locations to sites closer to the new facility. Thus, because of limited resources and the relatively small number of activities in a community, it is likely that there will be a shift in the spatial distribution of activities affecting the entire area. This is illustrated in Figure 7, p. 54. According to the assumptions of the survey-control area technique, the highway impact is measured as the change in the survey area minus the change in the control area. As a result, any negative effect in the control area will actually contribute to an increase in the total measured highway impact. Such a situation may occur frequently in small communities where major changes in the transportation system will cause businesses to move, resulting in both positive and negative effects in the area as indicated on Figure 7.

Thus, although the survey-control area approach is designed to correct for the limitations of the simple before-and-after study, in practice and in theory it has not been wholly successful. The problems involve finding a suitable control area, identical to the survey area in all respects except for the change in the highway facility, and isolating the impact on the survey area from the impact on the control area. The multitude of highway and non-highway related factors which are involved in the changes to be measured create a more complicated situation than the assumptions of the survey-control area method would account for.

Multiple Regression Analysis

This technique requires more information about the non-highway related factors than the other techniques, and it has in most cases been used when appropriate control areas could not be found. In this method the highway impact is isolated by examining both highway-related and non-highway-related factors. Consequently, the technique is not strictly limited to the analysis of highway impact, and it may also be used to analyze the complex cause/effect relationship in a more complete manner than do the previously described approaches. In practice, however, it has not been possible to include all relevant factors because of the lack of general knowledge about how to determine relevancy or how to quantify qualitative characteristics. At the same

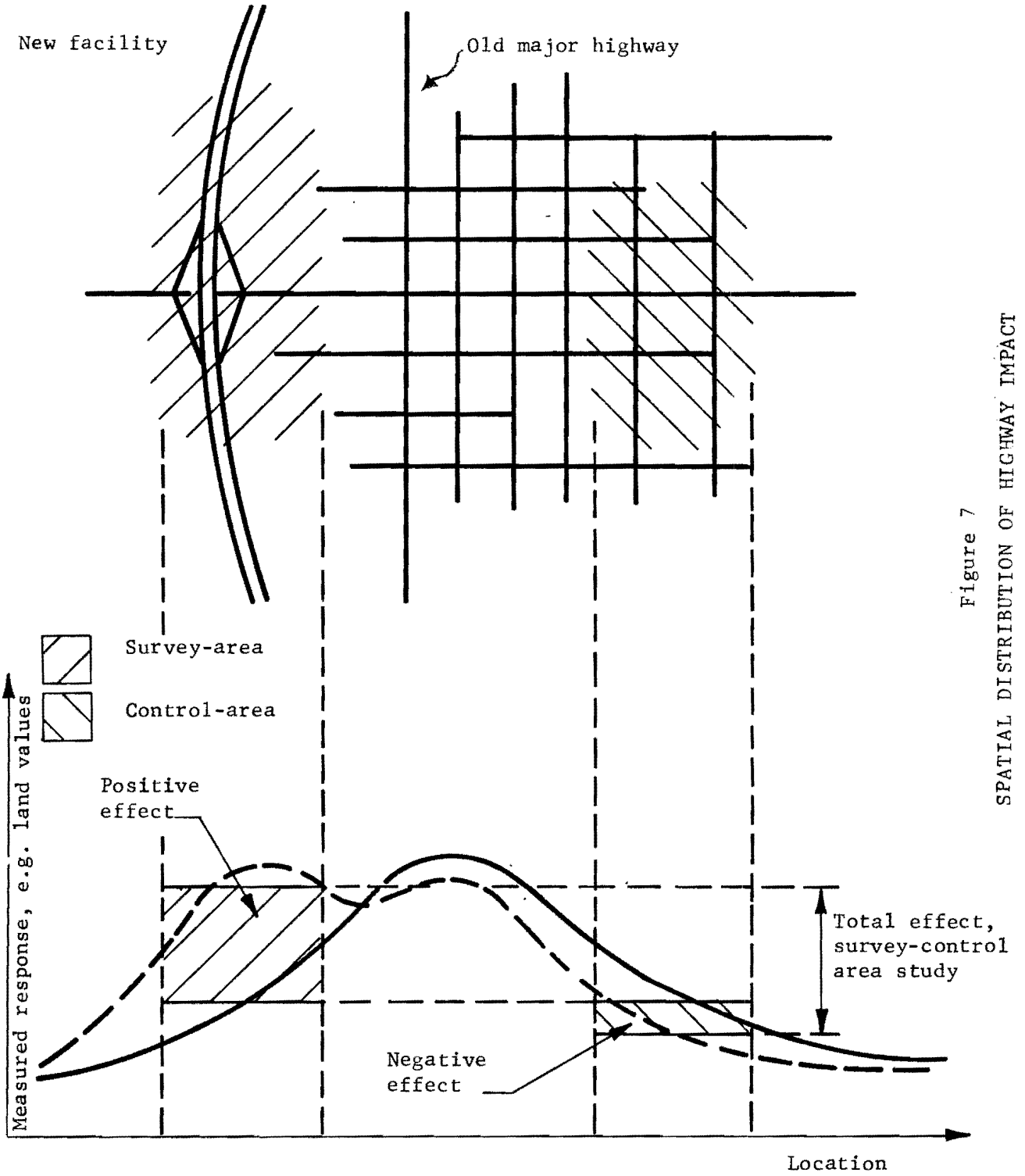


Figure 7

SPATIAL DISTRIBUTION OF HIGHWAY IMPACT

time, it is not always possible to gather sufficient data on those factors whose significance is known. However, these limitations do not apply to the methodology as such but rather to its present state of development.

The dependent variable in the regression equation is the specific area effect to be studied, e.g., land development or land value; the independent variables are all the relevant factors contributing to any part of the effect to be measured. By ordinary regression analysis, the best regression model can be found. The degree to which the included variables can explain the effect and an expression for the model's accuracy can be found.

In order to get a meaningful expression for the effect, all of the factors included in the regression model must be represented quantitatively. This creates great problems because many factors are qualitative, and no technique to give them a meaningful quantitative representation has yet been evaluated. This problem should be overcome, however, as more knowledge about the different factors involved in highway impact is acquired through future research.

Multiple regression analysis may be used together with a refined before and after approach to reveal information about changes in some community characteristic, e.g., land value, due to changes in both the transportation system and other aspects of the community.

It is important to be aware of the limitations connected to a regression model, especially since in most cases the model may seem to be general in character. The "best regression model" is entirely an empirical equation based on a given set of data, and it is not known whether the model can describe the effect when the range of any factor is extended beyond that in the data set previously analyzed. As "time" usually will be one factor in the model, it cannot be used for prediction of future impact unless certain assumptions about the future are made.

Case Studies

The case study approach deals with rather detailed analysis of specific events which have taken place. Such events may be as simple as the decision to construct a new industrial plant in a given location or as complicated as the whole set of events involved in the construction of a new transportation facility. The case study can be an intensive examination of the entire

situation in one specific area. Consequently, although detailed knowledge about the cause/effect relationship in the specific case may be obtained, the findings are not claimed to be general.

The value of a case study lies in the possibilities for detailed analysis, and thereby in providing experience on which broader studies of more general character can be based. Since general studies have to cover a wide spectrum of different cases, it is important to identify the most significant factors, to determine what information is available, and to establish the most efficient way of data processing and analysis.

Other Techniques

Techniques other than those discussed above have been used, but to very little extent. The major reason for this lies probably in the degree of complexity of the models and in the subjectivity of their assumptions.

One of these techniques is the "projected land use - value relationship approach." This technique is used for examining changes in land value, and it tries to take account of the close interaction between land use and land value as well as the acceleration or deceleration in land development. Realizing that land use may change in any case, highway improvement or not, the after situation cannot be directly compared to the before situation. To get a correct picture of the impact, the situation after highway improvement will have to be compared with a hypothetical projection of the before situation. Thus the researcher will have to make some general assumptions or do a thorough job of projecting land use development as it might have occurred supposing that no highway improvement took place. Because of the lack of sufficient information about trends in land use development in the before period, the projections often will have to depend on personal judgement and subjective assumptions. Personal judgement will also always be involved in determining land values in connection with the projected land use.

The projected land use - value relationship approach may be valuable in connection with other techniques. The projected land use may serve as a check on the appropriateness of control areas selected, or as a check on the actual highway impact affecting land use in an area close to a new highway facility.

A similar technique for evaluating the differences in impact on business activity in different locations is the "neutral road approach." Since the neutral facility cannot be physically constructed, it is a hypothesized road which can handle future traffic without causing any change in existing trends in land use development or business growth. The basic reason for adopting this approach is the necessity for retaining a perspective on over-all possibilities for area business volume in the future. It is expected that alternative highway locations will result in different predicted business volumes. The measurable effect is not the variation of each alternative from the neutral road, but the differences among the variations, which theoretically should be the result of facility location and design.

MAJOR SHORTCOMINGS OF PREVIOUS STUDIES

This discussion of the most commonly used methodologies in the previous transportation impact studies has revealed several shortcomings which should be observed when planning comprehensive impact studies. The comments should, however, be seen in connection with the actual study planned, and, consequently, simpler methodologies might be used for studies of limited character.

Most of the previous studies are limited in that they concentrate on a narrowly-defined study area. In studies of small towns in rural areas the entire community has to be included in order to provide a true picture of the total effect. In such communities, with limited resources and few existing activities, an increase in the activities in one particular area may have a detrimental effect in other areas of the community.

Today, the private automobile is the most common mode of transportation in the United States. In spite of this, an impact study should include in its analysis any transportation mode available in the community during the time period under consideration. Again, small communities may be very sensitive to, e.g., changes in railway services simply because in many cases they owed their initial development to rail transportation.

Many of the previous studies fail to give a good description of the total transportation system and other important community characteristics both before and after the improvement. For this reason it is difficult to see which

factors of the improvement are the most decisive and in what types of communities they will cause the specific effect predicted.

As a last major point, it may be added that the studies reviewed reveal little information about the time when an effect occurred relative to particular human decisions or physical changes. Public hearings, right of way designations, highway construction -- all are particular moments in a process and cannot be detached from the total cause/effect relationship.

REQUIREMENTS FOR FUTURE RESEARCH

In order to compensate for the limitations discussed above, an ideal study methodology will have to meet the following requirements:

(1) The study period must be long enough to include all the important changes in both the community and the transportation system.

(2) The study should be continuous over time to reveal the general trends in community development both before and after changes in the transportation system.

(3) The geographic limits of the study area must incorporate the entire community, including extraterritorial controls.

(4) The effects on the community examined must include all physical, social and economic factors of importance for characterizing the community and for measuring the community's potential for growth and development.

(5) The study of the transportation system must include all of the modes serving or influencing the community, and the study method must make it possible to determine what characteristics of the transportation system are of the greatest importance for community development.

The many weaknesses of the "before-and-after" and the "survey-control area" approaches would be overcome by employing a continuous long term study period. It would be necessary to make the study period continuous over the entire term, before, during, and following major changes in the intercity transportation system. This makes it possible to relate previous community conditions to later responses to change. Figure 8, p. 59, shows briefly the proposed technique.

The major feature of this approach is the ability to relate the indicator (s) under study to previous changes both in the transportation system and in the community itself. As an overall approach, it should be suitable

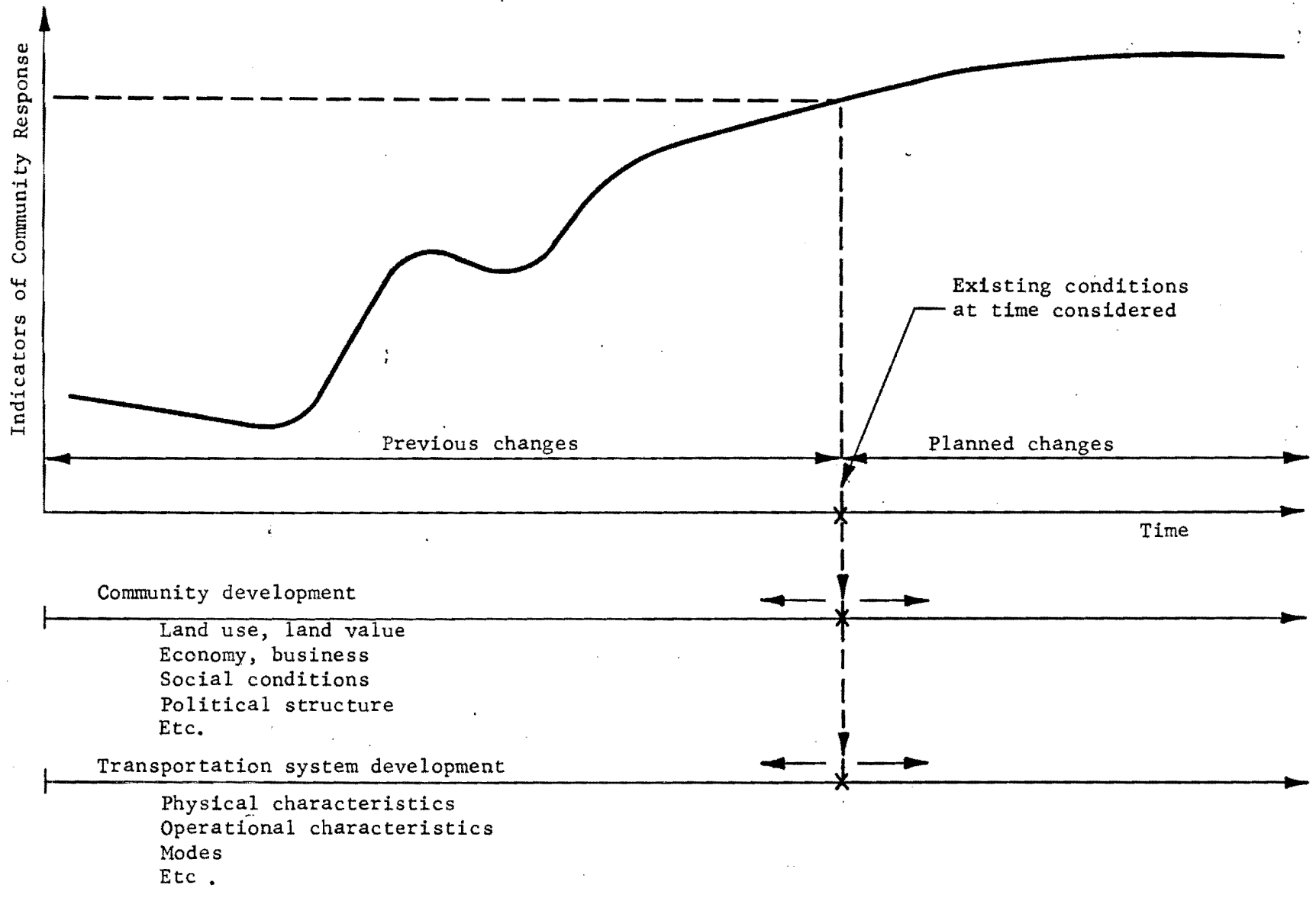


Figure 8
CONTINUOUS STUDY APPROACH

to any indicator capable of study, even though it is perhaps not feasible to use statistical analysis for all indicators. These may vary from directly measurable indicators, e.g., land value, to such less quantifiable indicators as the changes in community political and social structure. This general approach should make it possible to reveal the relationship between the effect in a community and the factors producing the effect. Consequently, for any case, it should be possible not only to describe what happened, but also to explain why it happened. Once the effects of transportation impact are more fully understood, it should be possible to develop more precise modeling techniques for those aspects of community change which can be related directly to changes in the transportation system.

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Nationwide study of manufacturing growth in 212 cities (population 10,000-50,000), 106 "freeway-cities" (< 7 miles from freeway) and 106 "non-freeway-cities" (>16 miles from freeway). The study findings indicate that modern highways do significantly affect manufacturing growth, but not in all situations. Freeway-cities grew faster only in regions where traffic flow along regular highways is seriously impeeded. The study also considers effect of air service, rail, waterways, and distance to freeway.

Wootan, C. V. and H. G. Meuth. "Economic Impact Study, Temple Texas." Texas Transportation Institute, Bulletin 14 (1960).

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Studies question: given shorter working days and/or shorter working weeks, how will future urban travel demands be affected?

Zinkefoose, Paul W. "Economic Survey of Raton, New Mexico - 1958-1966." New Mexico State University, Bulletin No. 37 (May, 1968).

The after portion of a highway impact relocation study. Discusses land values, businesses activity, employment, and general economic conditions.

_____. "Economic Survey of Anthony. New Mexico - Texas." New Mexico State University, Bulletin No. 41 (May, 1970).

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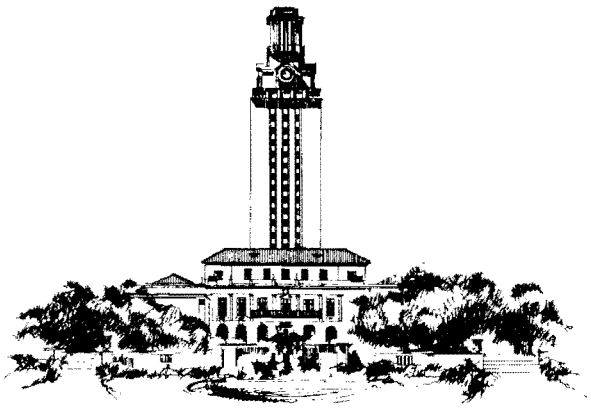

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